Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

JANUARY, 1948 DEPARTMENT

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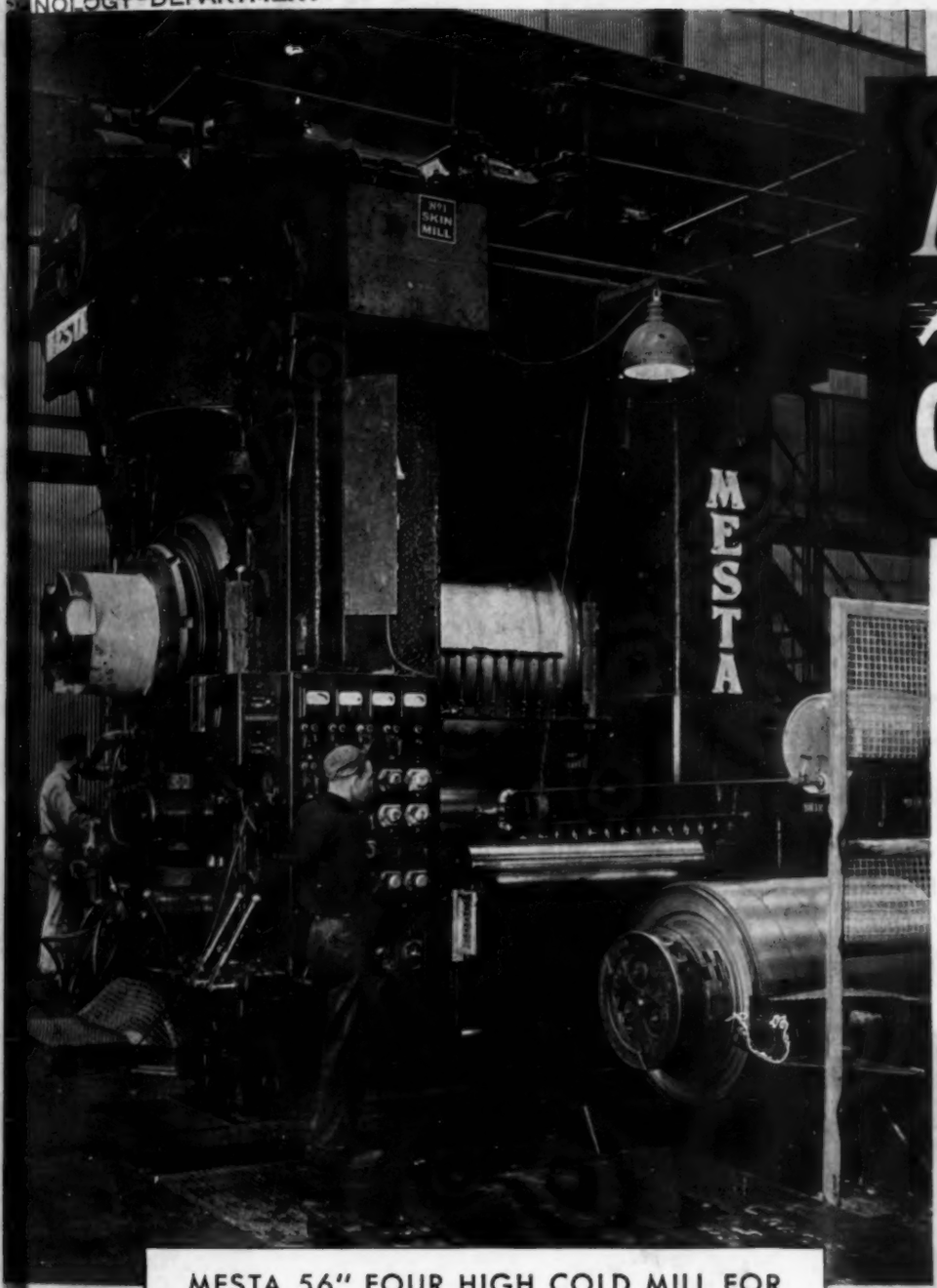


MESTA 56" FOUR HIGH COLD MILL FOR TEMPER PASSING OF SHEET GAUGES

Color Photo by Dan Reebel

MESTA
HIGHER SPEED
COLD MILLS

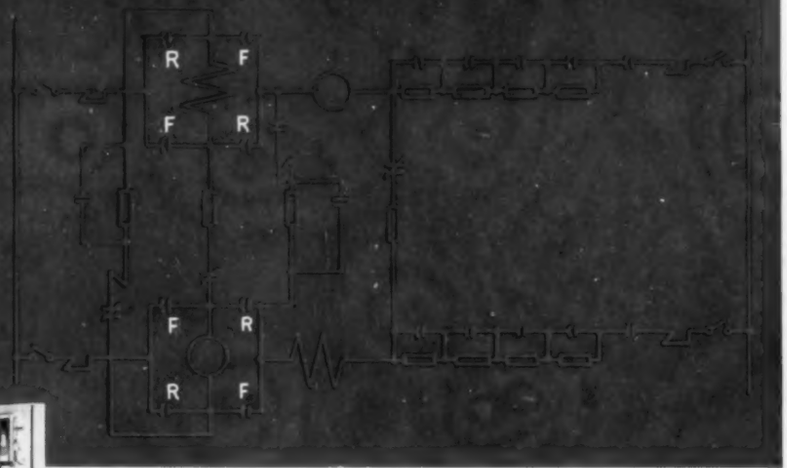
DESIGNERS AND BUILDERS OF COMPLETE STEEL PLANTS

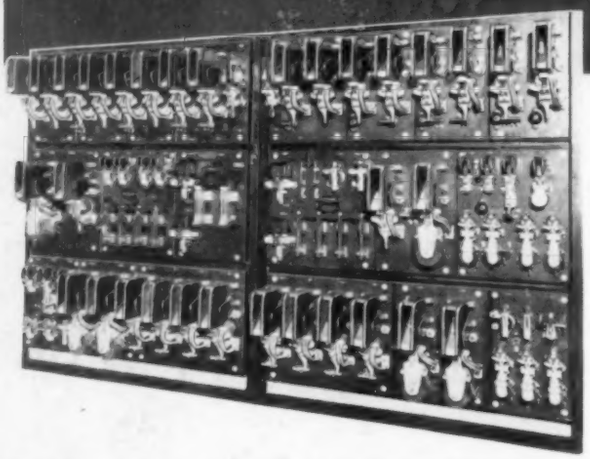
MESTA MACHINE COMPANY · PITTSBURGH, PA.

√R 125 Jan.-June 1948

What control for what mill equipment? One of a SERIES of advertisements featuring basic heavy duty power circuits . . . and showing Cutler-Hammer's broad design and application experience which has made it the preferred control for the steel industry.

When you have a two or four motor bridge drive on a crane or ore bridge . .





. . That calls for

Cutler-Hammer No. 14145 (Wilson-Ritchie) D. C. reversing Dynamic Braking Control

In addition to the unique Cutler-Hammer *Ltl* Inductive Time Limit method of acceleration, Cutler-Hammer Bulletin No. 14145 also employs the Wilson - Ritchie scheme in case of power failure for emergency dynamic braking on series wound motors.

This safety feature is gained by cross-connecting series fields and motor armatures to provide the correct polarity for dynamic braking by self-excitation. The feature may be used both for emergency stops and service stops. The contactors used are C-H standard, affording the ruggedness and simplicity that make Cutler-Hammer Mill Control outstanding.

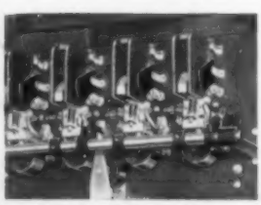
NOTE: As shown at left, Cutler-Hammer also makes available emergency dynamic braking for single motor applications as well. CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee 1, Wis. Associate: Canadian Cutler-Hammer, Ltd., Toronto.

CUTLER-HAMMER
MOTOR CONTROL
C-H

Typical Components of Cutler-Hammer Mill Control

Mill-type contactors whose reliability, life and low maintenance have made them the standard for industry.

Space Heaters provide easily installed, comfortable heat for operators in crane cabs, etc.

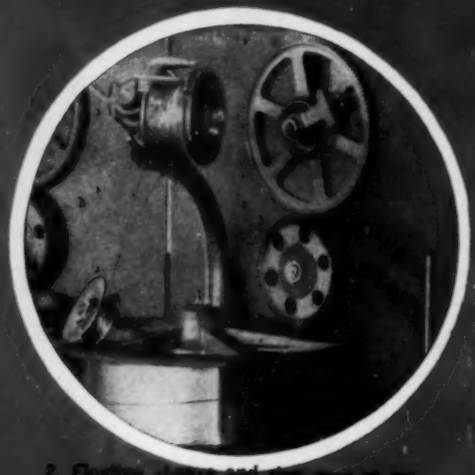


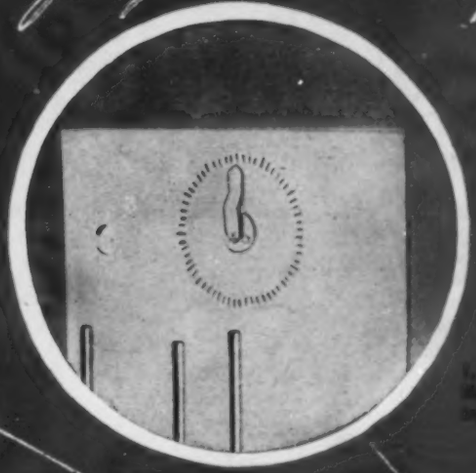
Emergency dynamic braking panel for single motor crane installations.

Techs

Aetna-Standard Multi-Unit Wire Drawing Machine

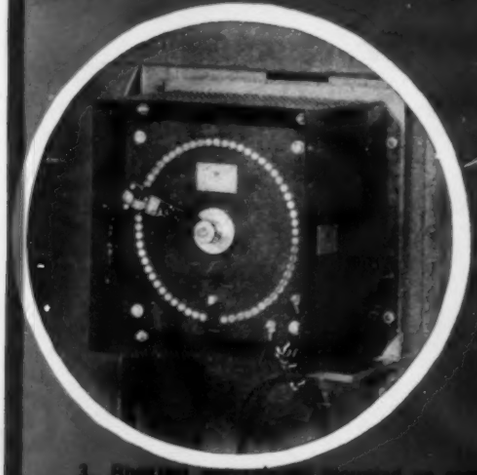
Auto-rheostatic synchronizing control system



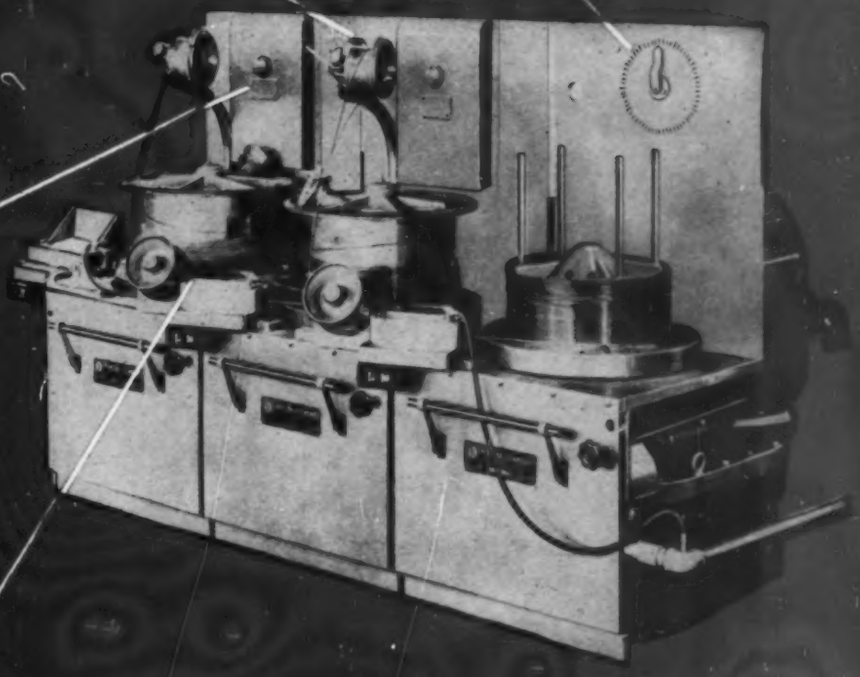


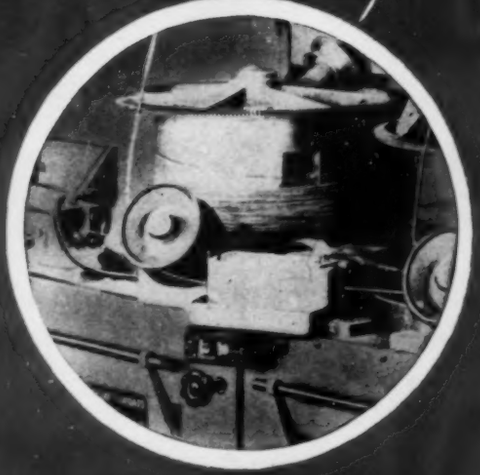
1. Hand dial and pointer for manual setting of wire drawing speed of leading unit.

2. Floating sleeve and ring gear at one of intermediate block automatic rheostatic control gearing automatically.



3. Rheostat control panel, mounted on rear of headpiece above vertical motor. Control mechanism permits full use of complete range of [illegible]





4. Ample reserve of wire on each block maintained at constant height automatically. Wire reserve can be varied by auxiliary manual rheostat control knob on each unit.

Heart of the automatic operation of two or more Aetna Units in tandem, centers in the auto-rheostatic synchronizing control, which automatically synchronizes block speeds to compensate for the elongation of the wire through successive drawing dies.

It is easy to operate. Once threaded, the Units will run automatically and continuously as long as a continuous strand of rod or wire is being supplied.

The Aetna Unit is available in four sizes (30"-22"-14"-12") for the production of heavy, medium, and light gauges of wire.

THE AETNA-STANDARD ENGINEERING COMPANY

YOUNGSTOWN, OHIO

ASSOCIATED COMPANIES:

HEAD, WRIGHTSON & COMPANY, LTD., THORNABY-ON-TEES, ENGLAND

AETNA-STANDARD ENGINEERING COMPANY, LTD., TORONTO, ONTARIO, CANADA

Alliance

OPEN HEARTH CHARGING MACHINES

LADLE CRANES

INGOT STRIPPING CRANES

SOAKING PIT CRANES

SLAB AND BILLET CHARGING MACHINES

FORGING MANIPULATORS

GANTRY CRANES

ORE AND COAL BRIDGES

SPECIAL MILL MACHINERY

STRUCTURAL FABRICATION

The Alliance Machine Company

MAIN OFFICE:
ALLIANCE, OHIO

PITTSBURGH OFFICE:
1622 OLIVER BUILDING, PITTSBURGH, PA.

for heavy thrust loads

● *Standardized SKF Spherical Roller Thrust Bearing for screw-downs, large speed reducer units, etc.*

The compact SKF Self-Aligning Spherical Roller Thrust Bearing is designed for mounting at all locations where heavy thrust loads predominate. Featuring a relatively small O.D. for a given bore, it is especially adaptable to such applications as worm drives, where minimum bearing centers on the worm shaft are an outstanding advantage. Capable of running at sustained high speeds and at remarkably low operating temperatures, it has all the desirable features. Let our engineers show you how it can best solve your thrust problems. 6371

SKF INDUSTRIES, INC.
Philadelphia 32, Pa.

SKF

SPHERICAL ROLLER THRUST BEARINGS

● *Double directional adaptation for the thrust location on 4-High Back-up Rolls equipped with any of the several types of oil film bearings to carry the radial load.*

Bleeding Ingots

bubbled out of existence

Today, "flushing" – bubbling a dry inert gas through metal just before casting – is the most efficient and economical method of eliminating "wild heats" or "bleeding ingots".

The test blocks shown on the left are typical examples. Both are 14% straight chrome stainless steel from the same heat. The test shown on the top, however, has a cheesy, porous structure – due to evolution of dissolved gas at the instant of freezing.

On the other hand, the bottom test block shows a perfectly dense structure – the result of flushing the molten metal prior to casting with an Airco inert gas – today's method for producing sound castings.

Airco Booklet ADR-35 gives you valuable information about this exceptional process which can be applied to both ferrous and non-ferrous metals. Fill in and mail the coupon for your copy. Air Reduction, 60 East 42nd Street, New York 17, N. Y. In Texas: Magnolia Airco Gas Products Company, Houston 1, Texas. Represented Internationally by Airco Export Corporation.

AIRCO

AIR REDUCTION

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Headquarters for Oxygen, Acetylene and other Gases . . . Carbide . . . Gas Welding and Cutting Apparatus and Supplies . . . Arc Welders, Electrodes and Accessories

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Please send me a copy of Airco's booklet ADR-35.

Name_____

Firm_____

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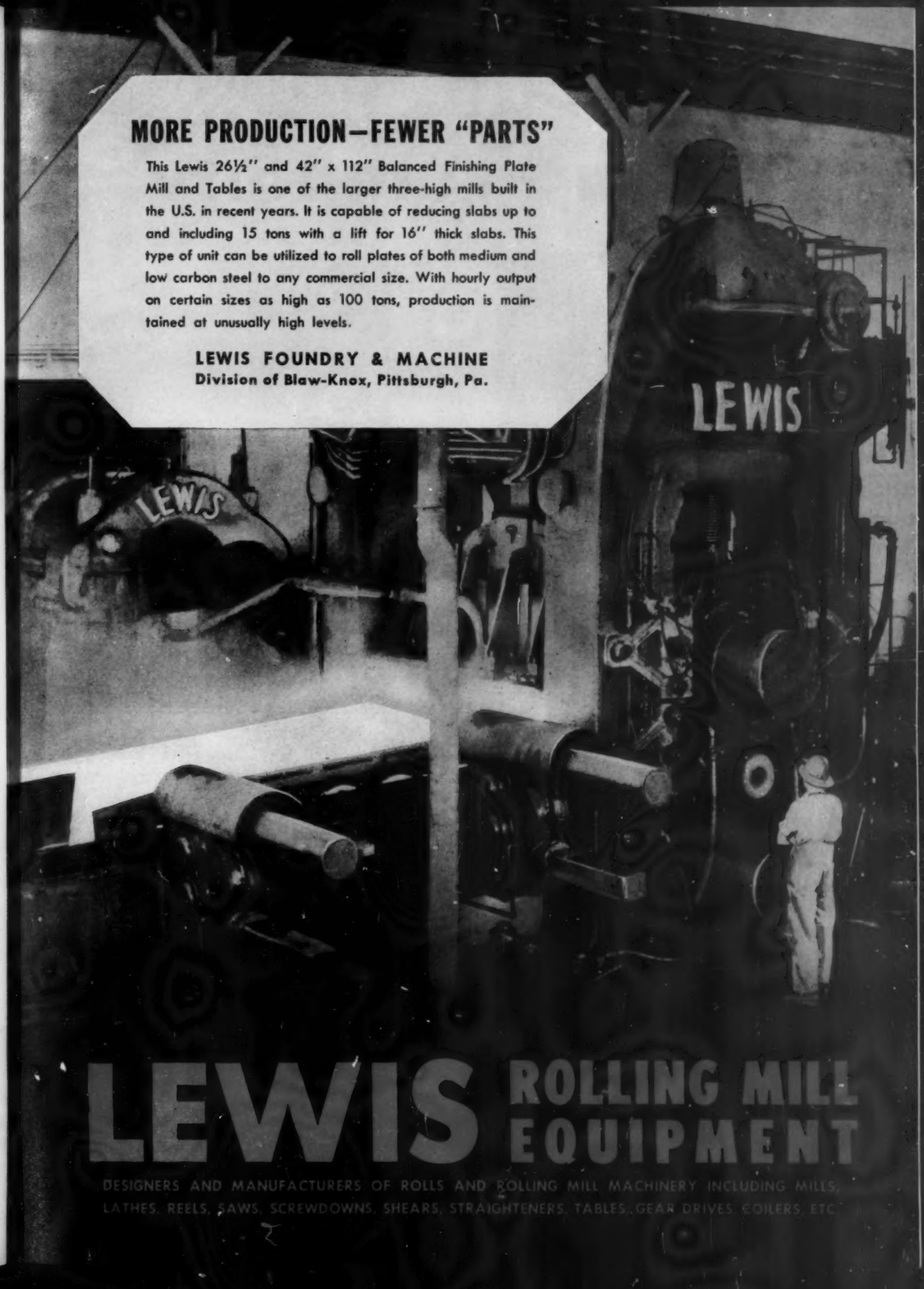
City_____ Zone____ State_____



MORE PRODUCTION—FEWER "PARTS"

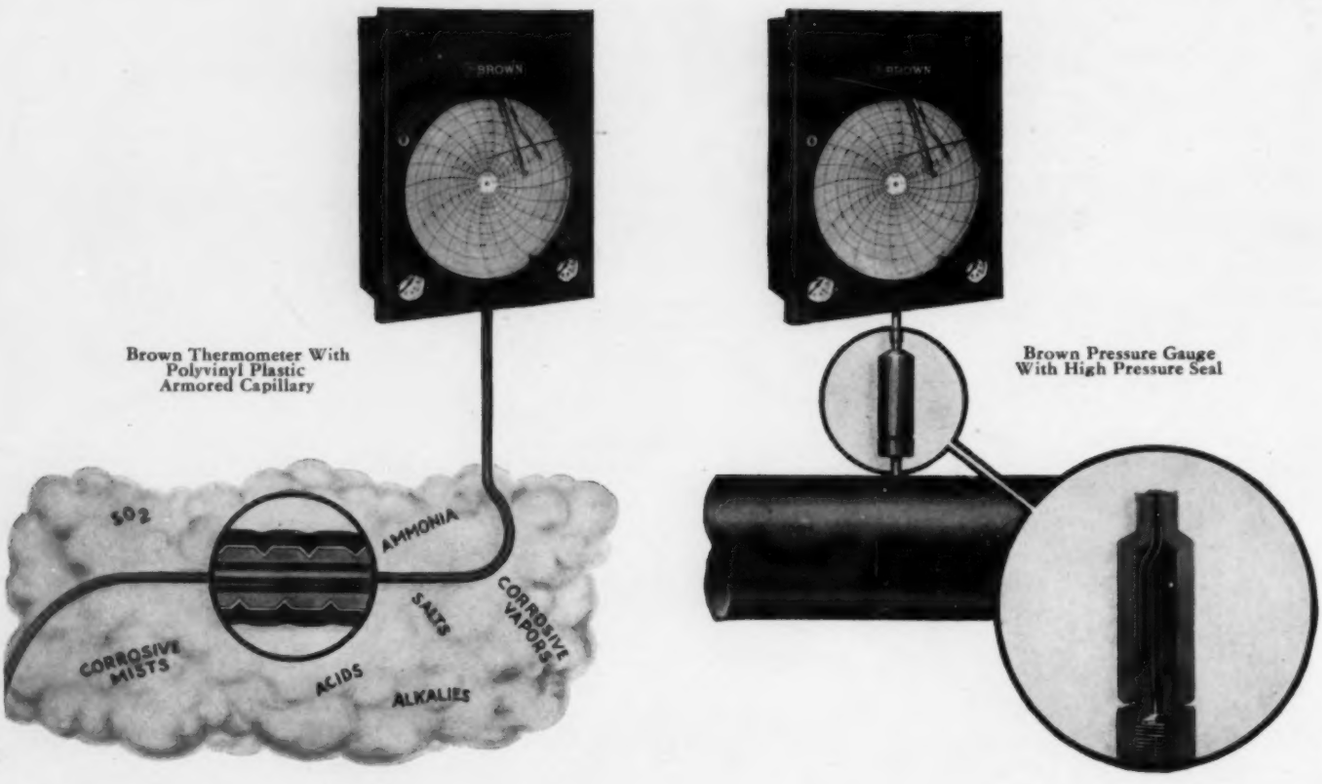
This Lewis 26½" and 42" x 112" Balanced Finishing Plate Mill and Tables is one of the larger three-high mills built in the U.S. in recent years. It is capable of reducing slabs up to and including 15 tons with a lift for 16" thick slabs. This type of unit can be utilized to roll plates of both medium and low carbon steel to any commercial size. With hourly output on certain sizes as high as 100 tons, production is maintained at unusually high levels.

LEWIS FOUNDRY & MACHINE
Division of Blaw-Knox, Pittsburgh, Pa.

LEWIS ROLLING MILL EQUIPMENT

DESIGNERS AND MANUFACTURERS OF ROLLS AND ROLLING MILL MACHINERY INCLUDING MILLS, LATHES, REELS, SAWS, SCREWDOWNS, SHEARS, STRAIGHTENERS, TABLES, GEAR DRIVES, COILERS, ETC.

Getting along in bad company



Survival of the fittest certainly applies to industrial instruments. Though precision instruments in every sense, they must withstand a collection of corrosive conditions that would rival the proverbial Hades.

Every Brown Thermometer and Pressure Gauge is protected against the usual tough conditions in Industry. You'll find that they stand up well and give performance even beyond normal expectations.

When the going gets too rough, the Brown Field Engineer has a number of strong-arm tools for use on extra tough applications.

A polyvinyl plastic covered capillary on thermometer systems will ward off a whole array of enemies to metal. Likewise, high or low pressure seals with the proper sealing medium will protect the delicate elements of a pressure gauge against most corrosive attacks.

These "little" considerations in design and application of instruments are why users have come to expect better and longer performance from Brown.

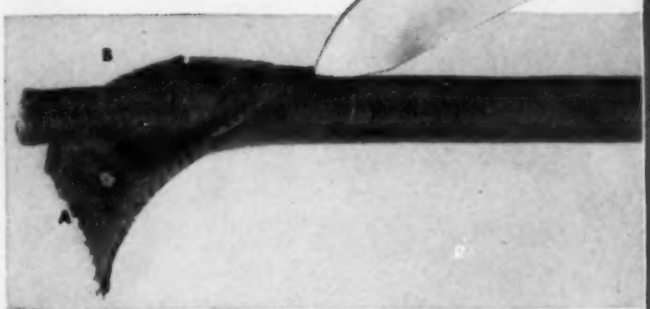
THE BROWN INSTRUMENT CO., 4464 WAYNE AVE., PHILADELPHIA 44, PA.
DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR CO.

Offices in principal cities of the United States, Canada and throughout the world.

BROWN *Advanced Instrumentation* FOR BETTER PROCESSING

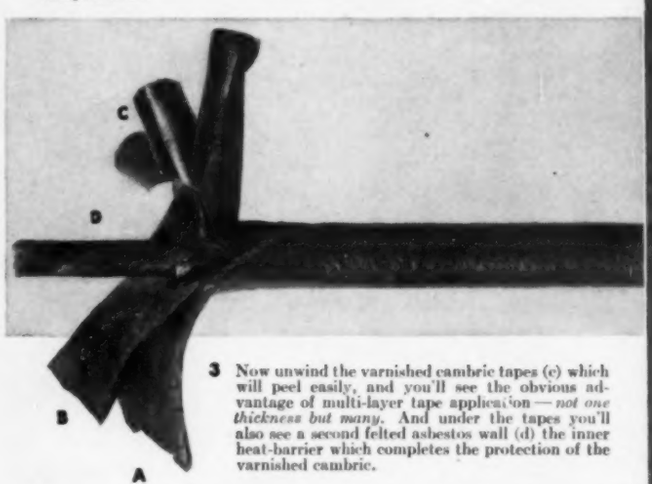
Product of MINNEAPOLIS **Honeywell**

For Resistance to Heat and Fumes LOOK Beneath the Braid



1 Take a sample of Rockbestos A.V.C. Power Cable, illustrated, or similarly insulated Motor Lead Cable, slit open the heavy asbestos braid (a) which is resistant to heat, flame, moisture, oil, and grease, and you'll find beneath a firewall of felted asbestos (b) a permanent heat-barrier against high ambient temperatures.

2 Then cut through this felted asbestos wall (b) peel it back, and see the high-dielectric moisture-resistant varnished cambric tape (c) it protects from heat, flame and oxidation. Notice, too, the uniform coverage of the tapes, helically applied like the felted asbestos to assure perfect and permanent centering of the conductor in the insulation.



3 Now unwind the varnished cambric tapes (c) which will peel easily, and you'll see the obvious advantage of multi-layer tape application — *not one thickness but many.* And under the tapes you'll also see a second felted asbestos wall (d) the inner heat-barrier which completes the protection of the varnished cambric.

4 Finally, slit and peel back this felted asbestos wall, (d) which prevents conductor-heating overloads from breaking down the varnished cambric, and you'll see the paper separator (e) that keeps the conductor clean of insulation and makes stripping easy. And that completes the story of Rockbestos A.V.C. *the wire with permanent insulation.*

A casual inspection isn't enough when it comes to selecting wire and cable for performance in hot-spot service. You've got to look *beneath* the braid! When circuits must operate next to boilers, furnaces, steam lines, drying ovens, resistor grids and soaking pits it is vitally important that the wire is *completely* insulated to withstand heat and moisture, corrosive fumes, oil, grease and flame.

The photos and text above tell the "inside story" of the reasons why Rockbestos A.V.C. Power, Motor Lead and Lighting Wires and Cables (National Electrical Code, Type AVA) will protect circuits and reduce maintenance . . . why their *permanent insulation* makes possible *continuous operation* at 230° F., under varied severe conditions without baking brittle, flowing or rotting.

Send for a sample, look beneath the braid, and see for yourself why Rockbestos A.V.C. gives more service per foot in the worst places. Several types for power, lighting and control circuits, switchboards and equipment, in 600 to 5,000 volt ratings. Just ask for what you are interested in. Write to:

ROCKBESTOS PRODUCTS CORP., 615 Nicoll St., New Haven 4, Conn.

ROCKBESTOS A.V.C.

The Wire with Permanent Insulation

125 different permanently insulated wires, cables and cords

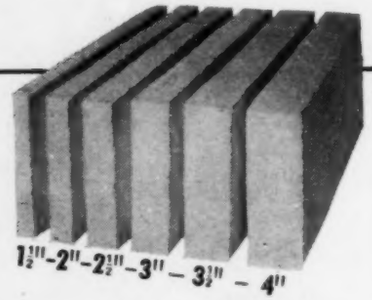
ROCKBESTOS

developed by Rockbestos for various severe operating conditions

NEW YORK CHICAGO BUFFALO CLEVELAND DETROIT
PITTSBURGH ST. LOUIS LOS ANGELES OAKLAND, CALIF.

Why the lowest cost open hearth producers use SUPEREX for regenerator insulation

The large size of the Superex blocks saves construction costs



Superex blocks are furnished in various standard sizes and thicknesses

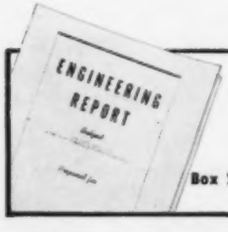
● "Insulate with Superex and you make substantial fuel savings and obtain higher operating temperatures," that's what cost-conscious operators find.

Superex provides these savings year after year. Made of calcined diatomaceous silica and asbestos, it presents a formidable heat barrier. It maintains its high insulating efficiency indefinitely on temperatures to 1900° F. . . . does not disintegrate . . . retains its high physical strength . . . resists the stresses of open hearth and other mill operations.

Higher operating temperatures with Superex result from its ability to reduce air infiltration. This advantage is traced to its unique structure and low permeability.

Superex is light in weight, easily cut and applied . . . comes in convenient standard sizes or may be ordered in irregular shapes.

To help you gain the greatest savings from Superex, Johns-Manville has prepared an engineering report, "Open Hearth Regenerators—a comparison of various insulation specifications." This report indicates the economic thickness of Superex to use as related to the costs of various types of fuels. To obtain this booklet, write Johns-Manville, Box 290, New York 16, N. Y.



TO OBTAIN THIS BOOKLET, WRITE
JOHNS-MANVILLE
Box 290, New York 16, N. Y.

JOHNS-MANVILLE *First in* **INSULATIONS**

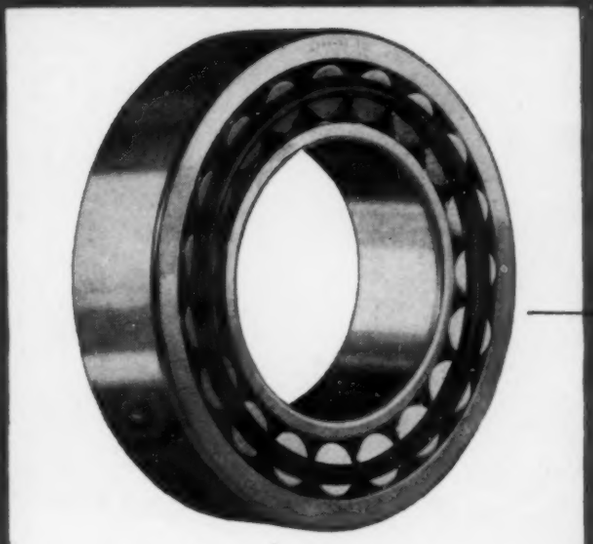
LINK-BELT "DE" SERIES

self-contained radial-thrust

Roller Bearings

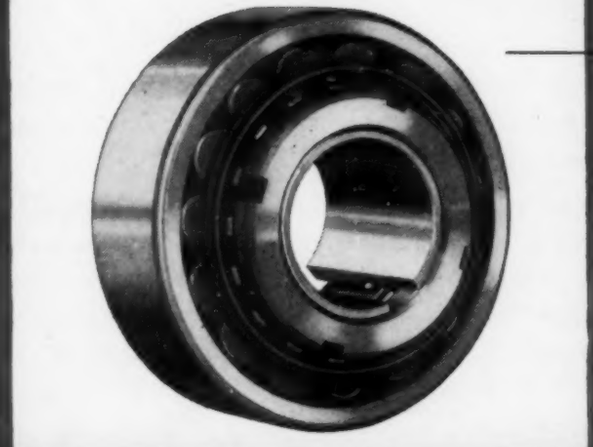
-- high load carrying capacity
-- no adjustment required
-- self-aligning
-- easily installed

One of the many stages of inspection in the manufacture of Link-Belt ball and roller bearings where accuracy and precision are assured.



Straight Bore Mounting

Series "DE" self-contained roller bearings for straight bore mounting are designed for press or shrink fits on shafting. They are turned and ground to precision diameters. This direct mounting of the bearing assures greatest smoothness in operation and increases its ultimate life.



Adapter Mounting

Series "DE" self-contained roller bearings for adapter mounting are designed for use with commercial shafting where ready means of removal and installation of bearing are advantageous. Tapered adapter sleeve supports inner race on shaft, providing a positive concentric mounting which adapts itself to commercial grades of cold finished shafting.

LINK-BELT

BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Houston 7, Los Angeles 33, Seattle 4, Toronto 8. Offices, Factory Branch Stores and Distributors in Principal Cities.

A Blower Record that "Plays Your Tune"

Here is some "mighty sweet music" if you are interested in lowering operating costs and maintaining production.

One of our 11,000 hp turbo-blowers was recently opened for inspection after six years of continuous service...and it was in *perfect* condition! This means that the original low Power consumption was not affected by use—Maintenance cost was nil —Availability was 100%.

Although we don't approve of neglecting the recommended annual inspection, this blower gave the peak performance demanded during the war and set a P-M-A record that is really something to sing about.

AIR TOOLS
COMPRESSORS
OIL AND GAS ENGINES
CONDENSERS • CENTRIFUGAL PUMPS

Ingersoll-Rand

11 BROADWAY, NEW YORK 4, N. Y.

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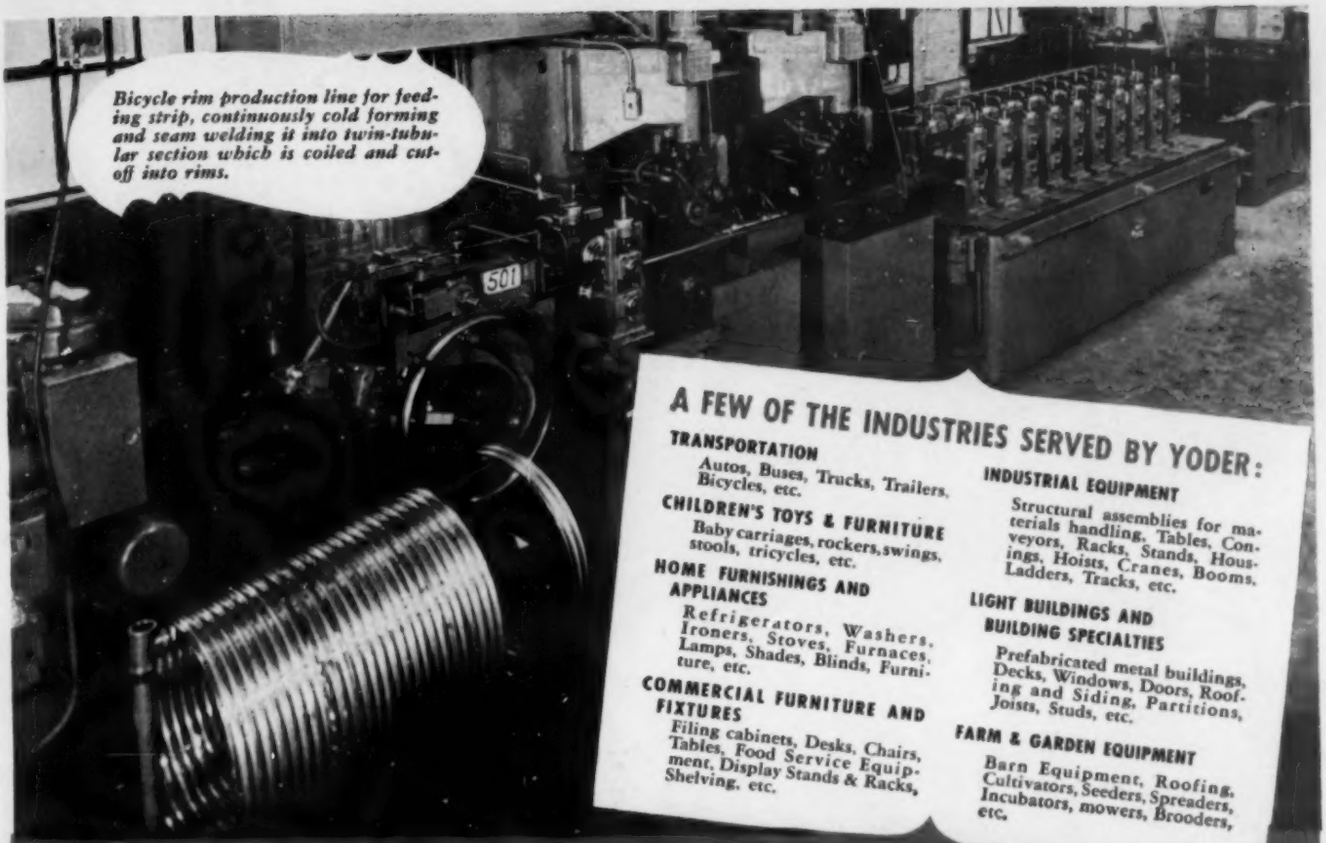


Bicycle rim production line for feeding strip, continuously cold forming and seam welding it into twin-tubular section which is coiled and cut-off into rims.

A FEW OF THE INDUSTRIES SERVED BY YODER:

TRANSPORTATION
Autos, Buses, Trucks, Trailers, Bicycles, etc.

CHILDREN'S TOYS & FURNITURE
Baby carriages, rockers, swings, stools, tricycles, etc.

HOME FURNISHINGS AND APPLIANCES
Refrigerators, Washers, Ironers, Stoves, Furnaces, Lamps, Shades, Blinds, Furniture, etc.

COMMERCIAL FURNITURE AND FIXTURES
Filing cabinets, Desks, Chairs, Tables, Food Service Equipment, Display Stands & Racks, Shelving, etc.

INDUSTRIAL EQUIPMENT
Structural assemblies for materials handling, Tables, Conveyors, Racks, Stands, Housings, Hoists, Cranes, Booms, Ladders, Tracks, etc.

LIGHT BUILDINGS AND BUILDING SPECIALTIES
Prefabricated metal buildings, Decks, Windows, Doors, Roofing and Siding, Partitions, Joists, Studs, etc.

FARM & GARDEN EQUIPMENT
Barn Equipment, Roofing, Cultivators, Seeders, Spreaders, Incubators, mowers, Brooders, etc.

A LOWER-COST PRODUCTION LINE

engineered especially for you!

If you make or are planning to make anything which can be fabricated from coiled strip, sheets or plate metal, the Yoder organization offers you, without obligation on your part, consultations, estimates and recommendations looking to low-cost, high-speed production through complete modern synchronized production line arrangements.

The Yoder staff concerns itself, first, with primary operations such as uncoiling of sheet metal, slitting, re-coiling and automatic feeding into cold forming machines, spot and continuous welding, curving, ring-forming, edge trimming, embossing, perforating and cutting-to-length. Additional operations may be included for fabrication and assembly of light structurals, tubing, mouldings, panels and trim into finished products, ready for the market.

In Yoder-engineered production lines, you get the benefit of their 35 years of specialization in the design, selection and synchronization of the latest and best in metal working tools and equipment, whether made by Yoder or other manufacturers.

THE YODER COMPANY
5495 Walworth Ave. • Cleveland 2, Ohio

ENGINEERING **YODER** MANUFACTURING

ROLL FORMING, TUBE MILL AND SLITTING MACHINERY

36 YEARS' LEADERSHIP • COILING • SLITTING • FORMING • EMBOSSING • CURVING • WELDING • CUTTING-OFF

Use your *OLD* tie-rods in your *NEW* pickling tank

NEW WOOD PICKLING TANK built by **The Hauser-Stander Tank Company,** *Cincinnati, Ohio. Its Monel tie-rods have already seen 7 years of continuous service in the old pine tank pictured at the left.*

Salvage of Monel rods both economical and practical, says HAUSER-STANDER TANK COMPANY, Ohio manufacturer

One test of a tie-rod's merit is its ability to keep a pickling tank tight.

Another, its ability to outlast the tank itself.

On both tests, Monel* tie-rods, nuts and washers show up exceptionally well.

So outstanding is their resistance to corrosive pickling solutions, that **The Hauser-Stander Tank Company** of Cincinnati, Ohio, frequently suggests re-use of Monel tie-rods in new tanks!

Note the illustrations on this page. One tank is new; one is old. *But the tie-rods are the same.* Hauser-Stander took them from the old pine tank where they had seen seven years of continuous service, and used them to bind the new tank.

On occasion, Hauser-Stander has taken Monel rods which have served in *two* wooden tanks, and put them into a *third.* It's possible to do this because corrosion-resistant Monel combines high strength and high yield point with high ductility. Even under severe conditions, Monel retains these properties. That's why it is also possible to take old tie-rods and fabricate them into hooks, eyebars or pickle pins.

When you order new tanks — or find it necessary to re-rod those you have — remember Monel. It's long-lasting. It's safe. It's economical.

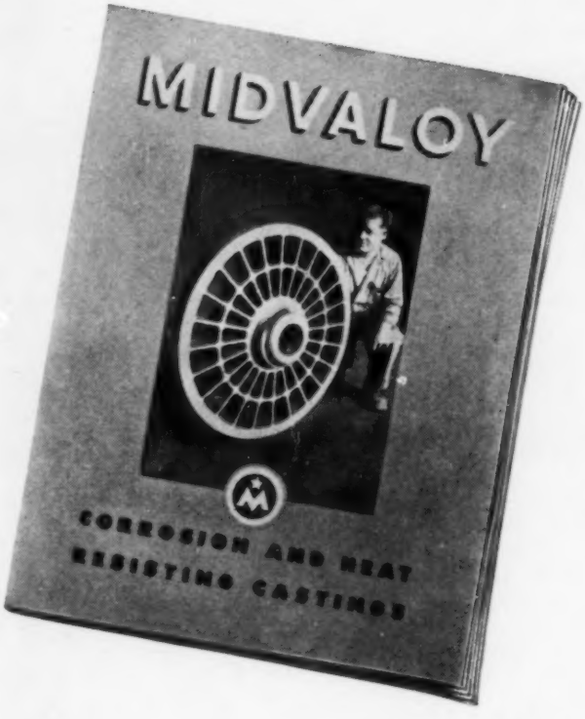
Monel

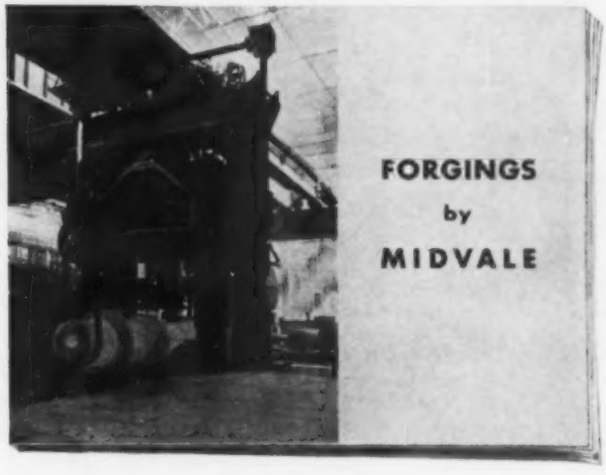
EMBLEM OF SERVICE
NICKEL INCO TRADE MARK ALLOYS
THE INTERNATIONAL NICKEL COMPANY, INC., 67 Wall Street, New York 5, N.Y.

*Reg. U. S. Pat. Off.

ALL ABOUT FORGINGS, STAINLESS CASTINGS, TOOL STEELS

Midvale's three new descriptive catalogs on Forgings, Stainless Castings and Tool Steels are required reading for 1948. The best way to start the New Year—ask for copies of the catalogs which will interest you. They are new, complete, full of up-to-date information on *custom steels.*





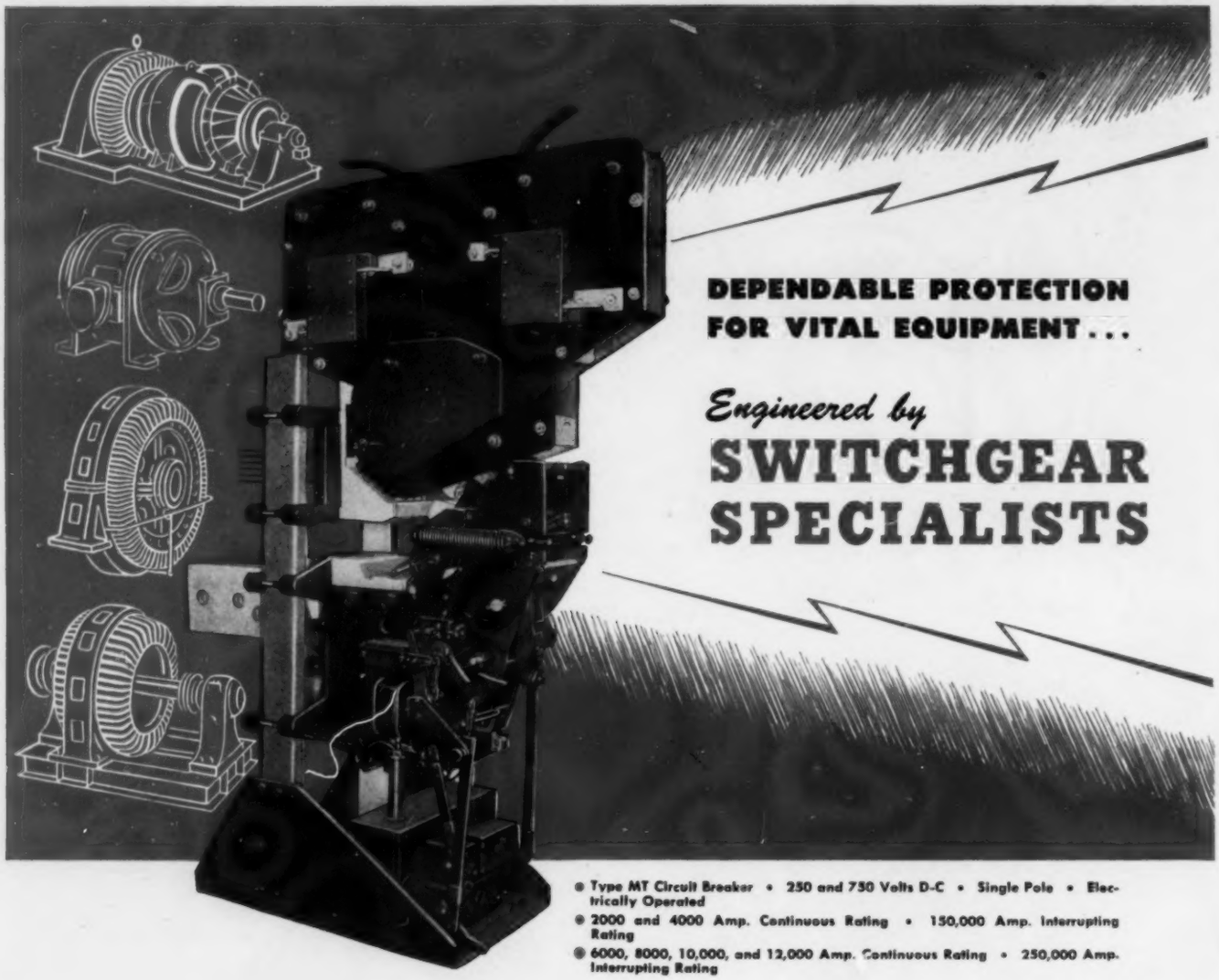
THE MIDVALE COMPANY • NICETOWN • PHILADELPHIA

OFFICES: NEW YORK • CHICAGO • PITTSBURGH
WASHINGTON • CLEVELAND • SAN FRANCISCO

MIDVALE

Custom Steel Makers to Industry

STAINLESS AND TOOL STEEL BARS
•
CORROSION AND HEAT RESISTING CASTINGS
•
FORGINGS AND RINGS



DEPENDABLE PROTECTION FOR VITAL EQUIPMENT . . .

Engineered by

SWITCHGEAR SPECIALISTS

- Type MT Circuit Breaker • 250 and 750 Volts D-C • Single Pole • Electrically Operated
- 2000 and 4000 Amp. Continuous Rating • 150,000 Amp. Interrupting Rating
- 6000, 8000, 10,000, and 12,000 Amp. Continuous Rating • 250,000 Amp. Interrupting Rating

PROTECT your vital power machinery from the hazards of electrical disturbances more dependably, more efficiently with the I-T-E Type MT Circuit Breaker. The MT helps you avoid expensive repairs, replacements, and production shutdowns because of electrical disturbances; and cuts operating costs by reducing necessary maintenance and attendance.

The quick acting MT interrupts extremely heavy direct-currents in about 1¾ cycles (60 cycle basis) at 25% to 100% of interrupting capacity. All tripping devices are direct acting and instantaneous; short circuits are cleared rapidly and dependably. The valuable *Rate-of-current-rise Trip* distinguishes between a useful load of high value and a dangerous fault current, and trips the breaker before the danger peak is reached—preventing possible damage to cables and connected equipment. The MT is electrically and mechanically trip-free on overcurrent, and trips immediately when closed on a fault.

Ruggedly constructed for heavy duty, the MT main contacts are solid blocks of copper with ample cross section to carry rated currents. Pure silver inserts keep contacts free from oxidation and overheating. Secondary contacts protect the main contacts from arcing damage.

The MT is normally built in two styles; one for panel mounting, the other for pedestal mounting. Truck mountings can also be furnished, if desired. Each style has the same rugged frame of hot-rolled steel, welded into a sturdy support unit.

Complete technical information on the I-T-E Type MT Automatic Reclosing Circuit Breaker is contained in illustrated catalog 2201. Send for your copy. *The I-T-E representative in your locality will be glad to advise you on applying the MT—and other I-T-E protective Switchgear—to your electrical distribution system. Use his services without obligation.*

I-T-E

MILL TYPE SWITCHGEAR

The Leader In Technical Excellence

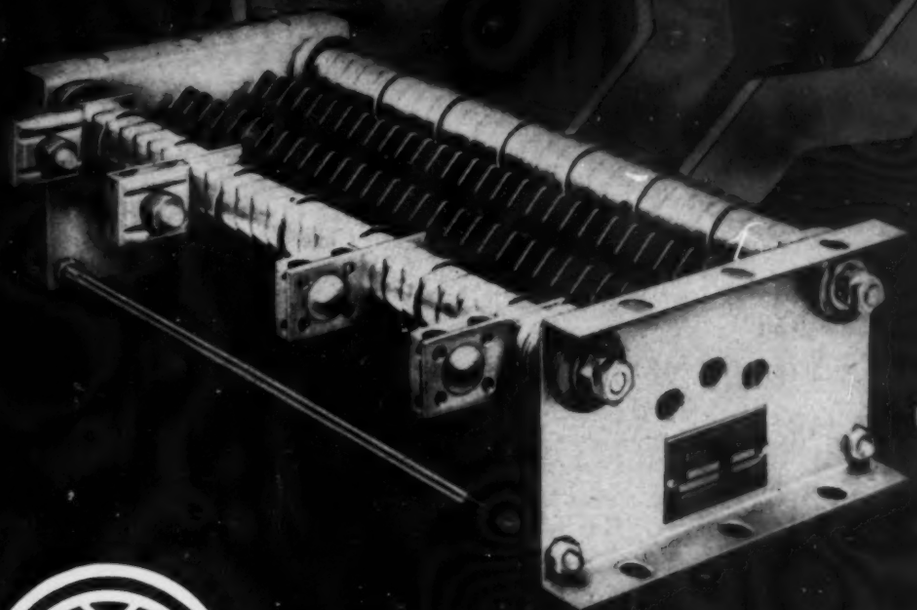
I-T-E CIRCUIT BREAKER CO., 19TH & HAMILTON STS., PHILADELPHIA 30, PA.—31 OFFICES IN UNITED STATES AND CANADA

SWITCHGEAR • UNIT SUBSTATIONS • ISOLATED PHASE BUS STRUCTURES • AUTOMATIC RECLOSING CIRCUIT BREAKERS • HIGH SPEED CIRCUIT BREAKERS

ONLY...P-G *Steel Grid Resistors*

OFFER THESE FEATURES...

Non-Breakable • All Steel Construction • Mica Insulation • Corrosion Resistant • Unaffected by Vibration or Moisture • Provision for Expansion • Adequate Ventilation • Rugged Terminals



THESE FEATURES COMBINED INSURE LONG RESISTOR SERVICE LIFE

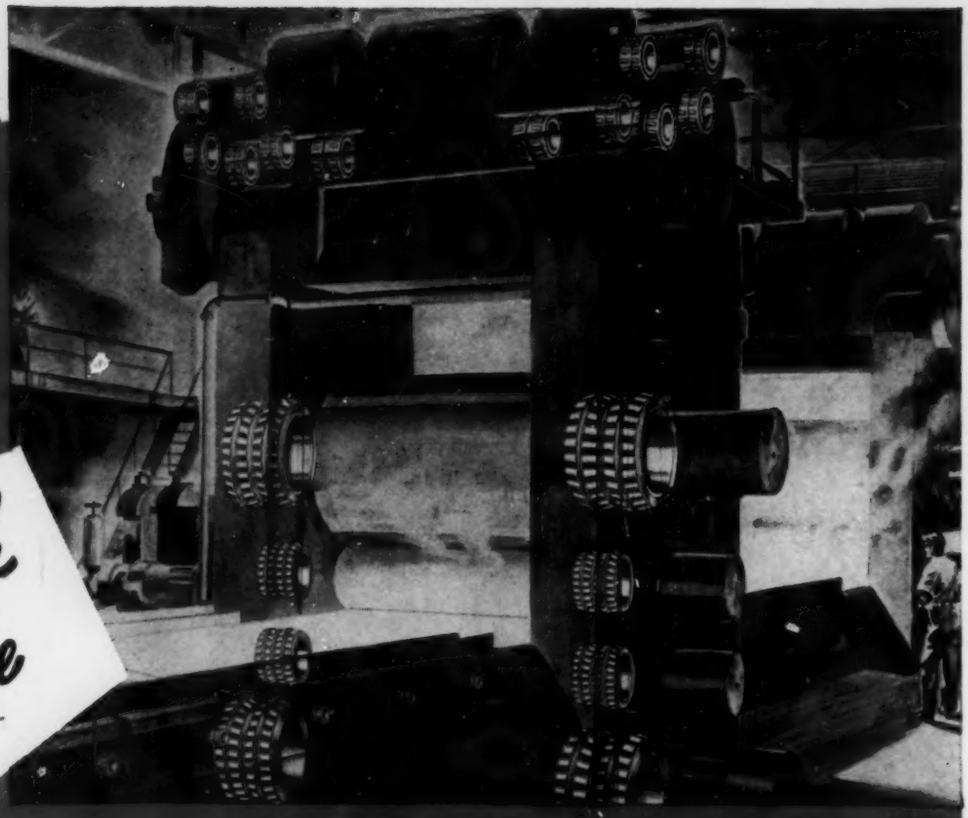
P-G

The Nonbreakable Steel Grid Resistor

THE POST-GLOVER ELECTRIC COMPANY

• ESTABLISHED 1892 •

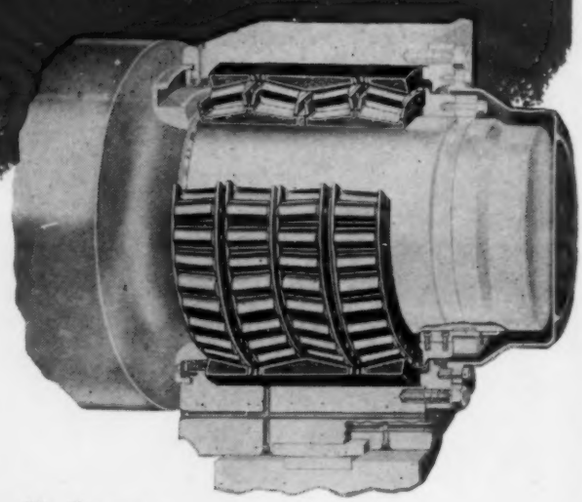
221 WEST THIRD STREET, CINCINNATI 2, OHIO



Let's look into the

Current Rolling Mill Bearing Situation

Now, through *balanced proportion* design, the Timken Roll Neck Bearing makes possible 50% to 60% greater roll neck strength with correspondingly reduced roll neck stress and deflection, thereby assuring greater mill and bearing rigidity and producing still higher rolling precision.



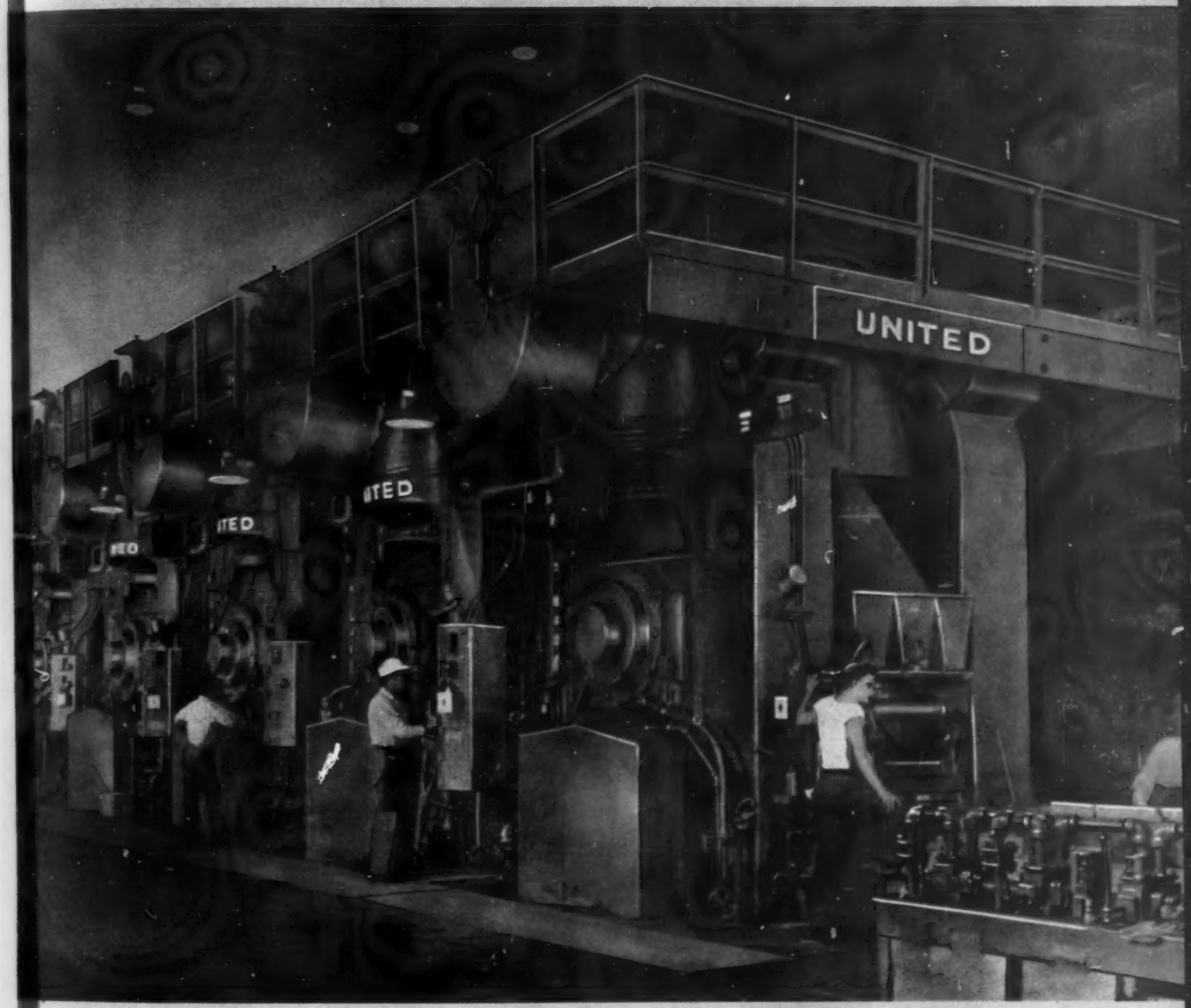
To sum up the current roll neck bearing situation, there is now no need for you to deny yourself the advantages and economies of roller bearings in your rolling equipment; no need for complicated and expensive lubricating systems; no need for making routine roll changes more difficult and time-consuming.

For specific information covering the application of Timken Balanced Proportion Roll Neck Bearings in new or existing mills — any type, hot or cold — consult the mill builder or our engineers. The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN
TRADE-MARK REG. U. S. PAT. OFF.
ROLL NECK BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ⊂⊃ THE TIMKEN TAPERED ROLLER ⊂⊃ BEARING TAKES RADIAL ⊕ AND THRUST →⊕← LOADS OR ANY COMBINATION →⊕←

UNITED



42"—4 High, 5 Stand COLD STRIP Mill capable of rolling tin plate at speeds up to 5000 feet per minute.

A Product of

UNITED ENGINEERING AND FOUNDRY COMPANY

PITTSBURGH, PENNSYLVANIA

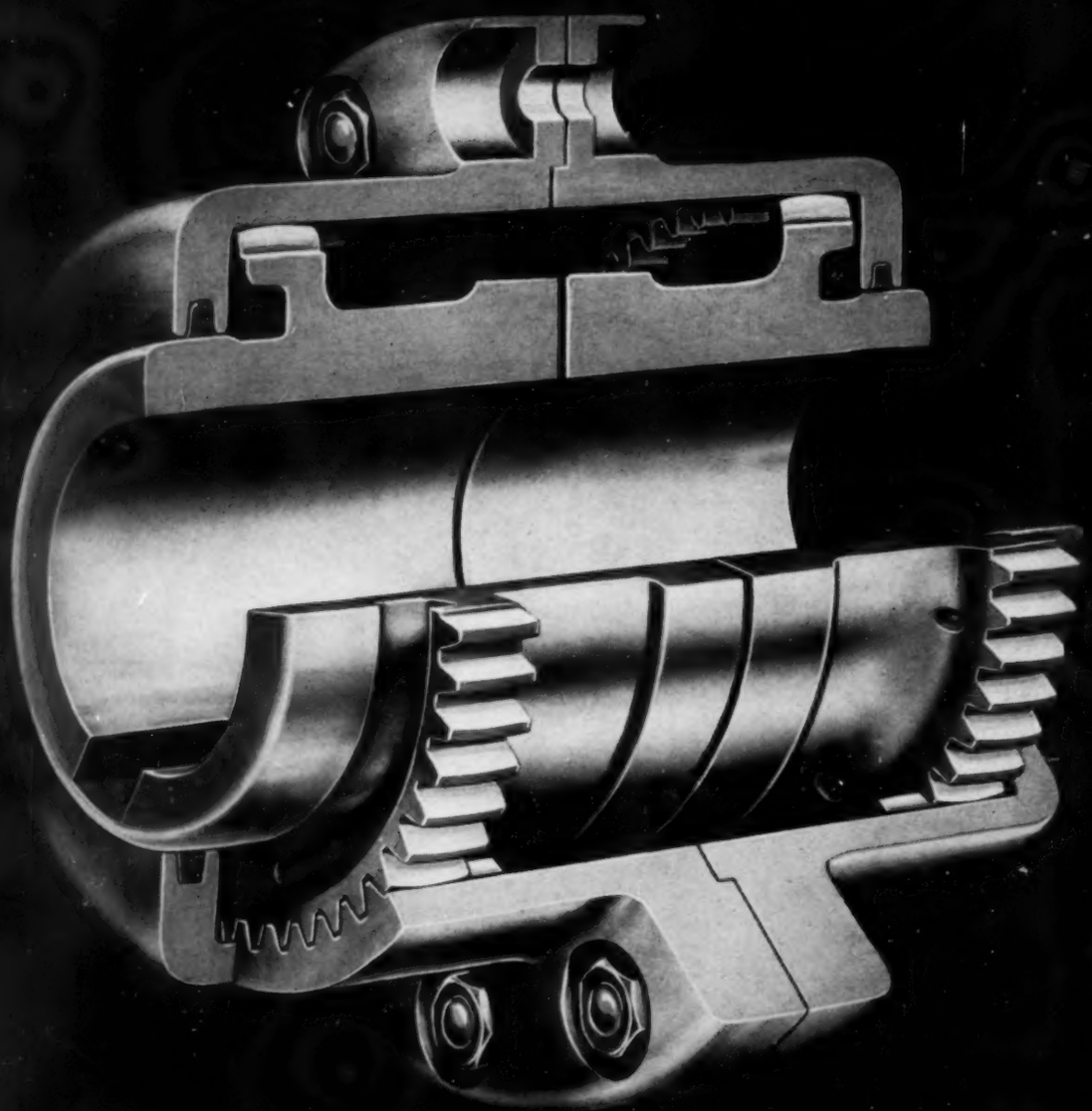
Plants at PITTSBURGH • VANDERGRIFT • NEW CASTLE
YOUNGSTOWN • CANTON

Subsidiary: Adamson United Company, Akron, Ohio

Affiliates:
Davy and United Engineering Company, Ltd., Sheffield, England
Dominion Engineering Works, Ltd., Montreal, P.Q. Canada
S.E.C.I.M., Paris, France

UE&FCO

POOLE



A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUES

FLEXIBLE COUPLINGS

POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, M

The WEAN ENGINEERING COMPANY, Inc.

WARREN, OHIO

Associate Companies

WEAN EQUIPMENT CORPORATION
Cleveland, Ohio

THE McKAY MACHINE COMPANY
Youngstown, Ohio

FLINN & DREFFEIN ENGINEERING COMPANY
Chicago, Illinois

THE HALLDEN MACHINE COMPANY
Thomaston, Connecticut

THE DREVER COMPANY
Philadelphia, Pennsylvania

THE WEAN ENGINEERING CO. OF CANADA, LTD.
Hamilton, Ontario

REPRESENTATIVES

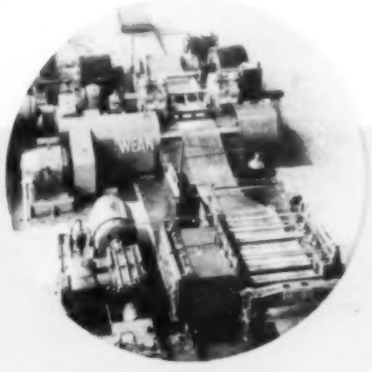
ENGLAND

JOHN MILES & PARTNER
(London, Ltd.)
London, England

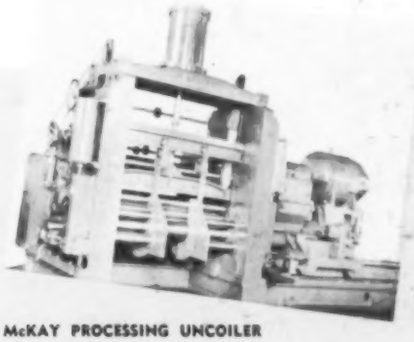
FRANCE

DOCUMENTATION & LICENSES
Paris, France

CONTINUOUS STRIP PICKLING LINES



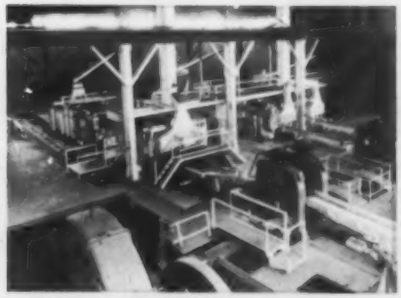
SIDE TRIMMING AND SHEARING LINE



McKAY PROCESSING UNCOILER

TIN PLATE SHEARING LINE

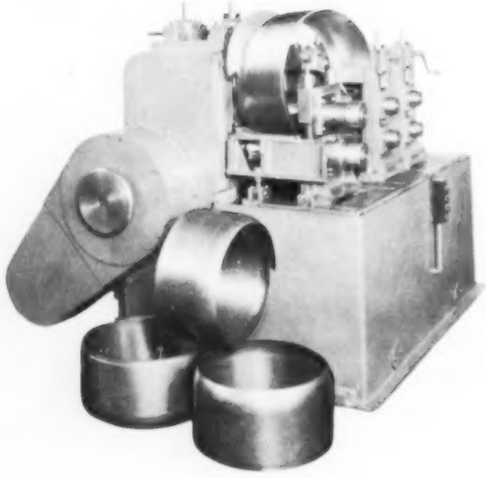
ELECTROLYTIC COATING UNIT



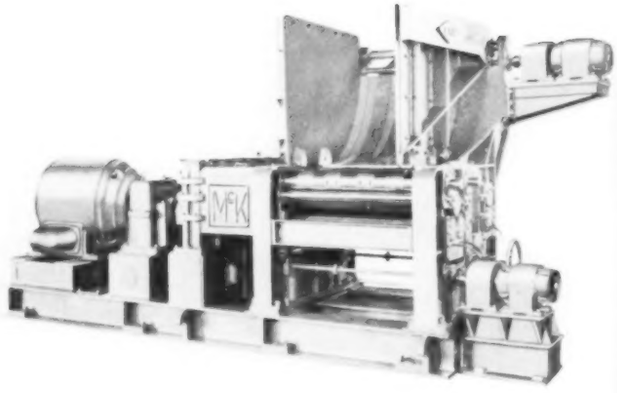
MECHANIZED SHEET MILL

SPECIALISTS IN SHEET, TIN AND STRIP MILL EQUIPMENT

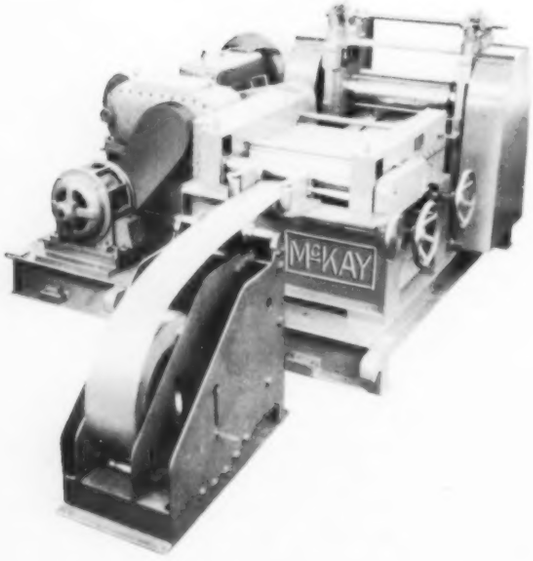
McKAY



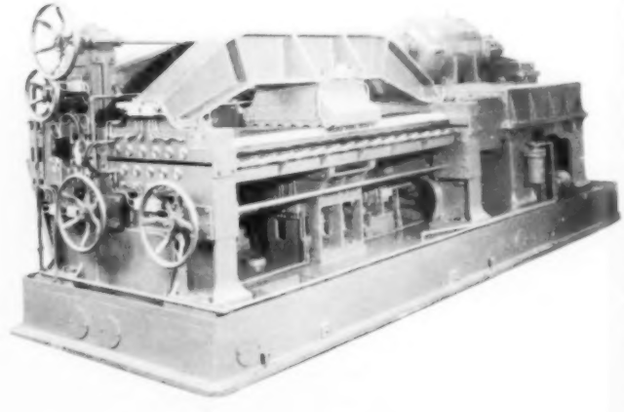
SPECIAL COLD ROLL FORMING EQUIPMENT
Designed and built in a complete range of sizes to meet customer's requirements.



AN ENTIRELY NEW UPCOILER
Designed for rolling mill service with many important new features.

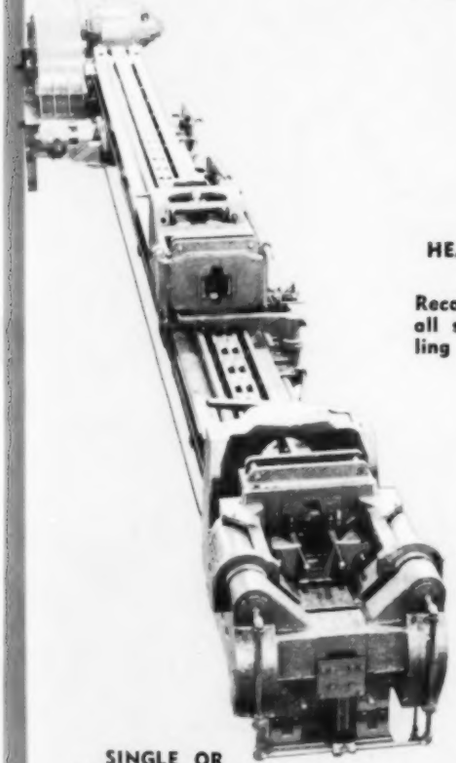


AUTOMATIC CUT TO LENGTH UNIT
Composed of roller leveler and rotary shear—for coiled strip 6" to 48" wide.



BUDD-McKAY PROCESSORS
Recognized as being indispensable for processing sheet metal before die drawing.

McKAY'S progressive engineering service to steel mills, automotive and fabricating industries has been implemented by an up-to-date engineering department and enlarged manufacturing facilities. Our sole objective is to design and build low-cost, high-speed equipment to give you greater production at lower cost.



SINGLE OR MULTIPLE DRAW BENCHES

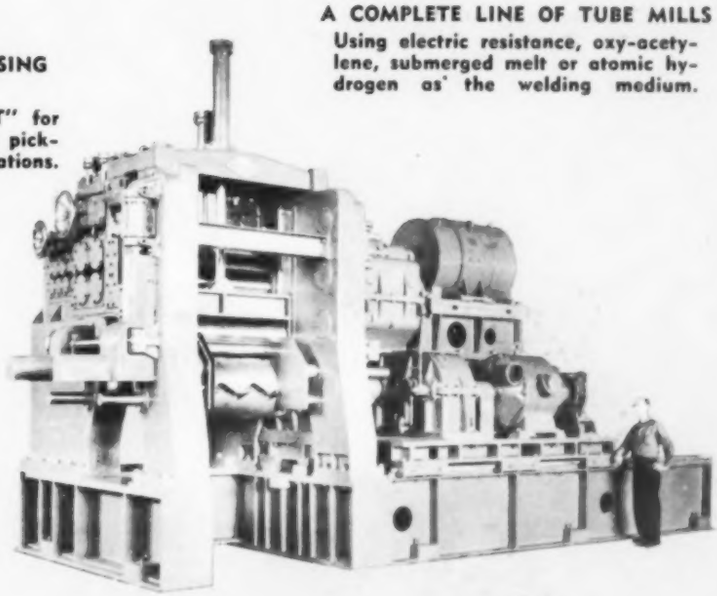
For bars and tubes, in a complete range of capacities, with push pointers and other auxiliary equipment.

HEAVY DUTY PROCESSING UNCOILER

Recognized as a "MUST" for all steel mill continuous pickling and cut-up installations.

A COMPLETE LINE OF TUBE MILLS

Using electric resistance, oxy-acetylene, submerged melt or atomic hydrogen as the welding medium.



The McKAY MACHINE Company

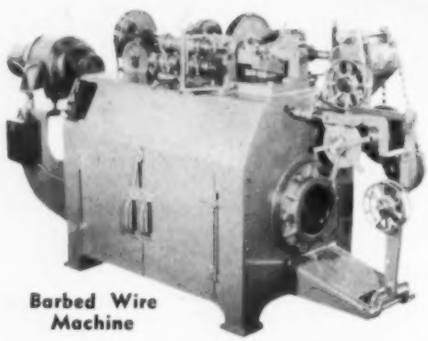
ENGINEERS AND MANUFACTURERS OF SHEET, TIN, AND STRIP MILL EQUIPMENT

YOUNGSTOWN, OHIO

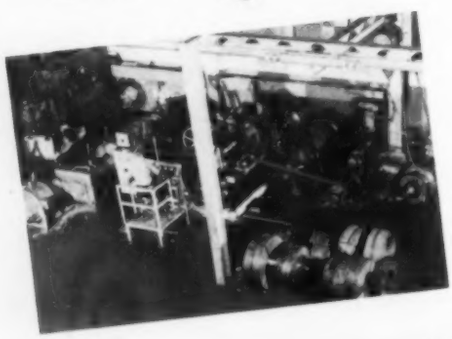
ASSOCIATED COMPANY The WEAN ENGINEERING CO., Inc. • WARREN, OHIO

Wean EQUIPMENT Corporation

8-inch Single Strand
Wire Flattening Mill
With Wire Straighteners



Barbed Wire
Machine



Wean
Slitting Line

The WEAN EQUIPMENT CORPORATION is recognized as a specialist in high-efficiency strip and wire mill equipment.

COLD ROLLING MACHINERY

For 36" Wide Material and Narrower

MILLS — REELS — SLITTERS — LEVELERS
COILERS — EDGERS — SCALE BREAKERS — SHEARS
SCRAP BALLERS — CONTINUOUS PICKLING

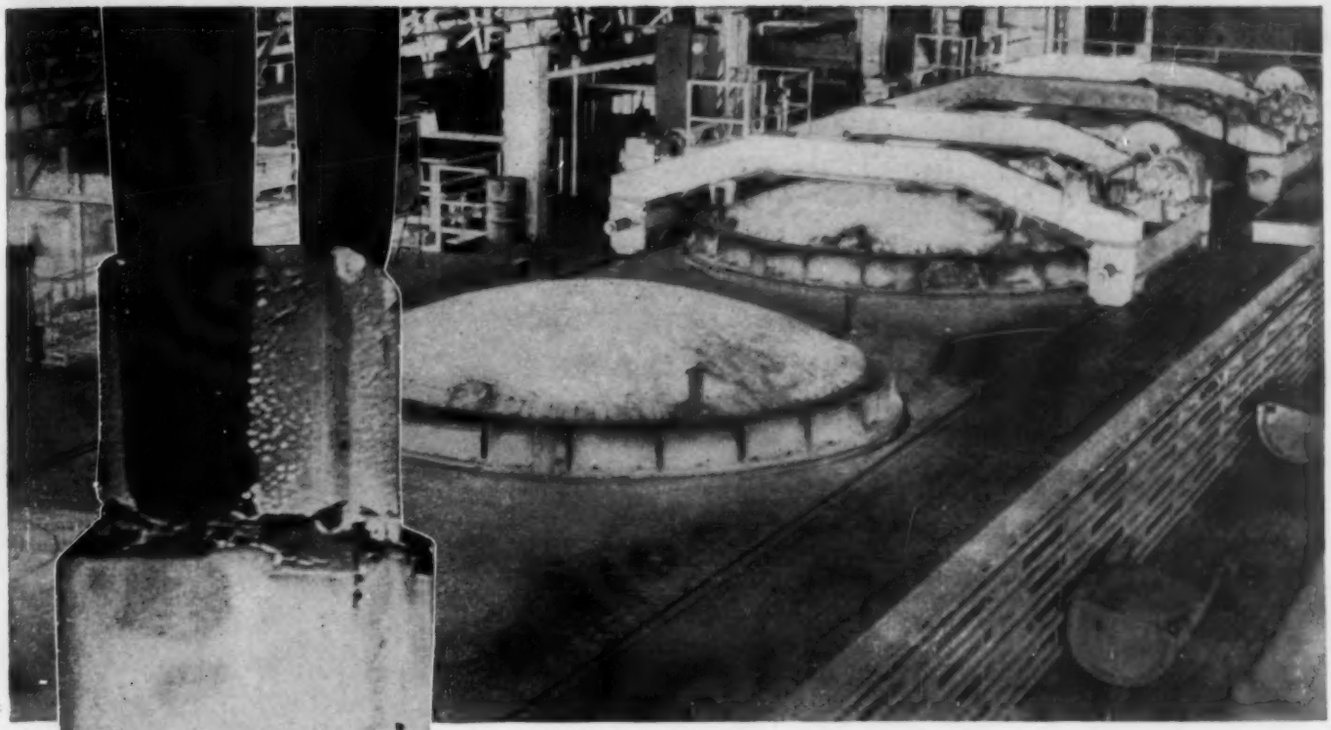
WIRE MILL EQUIPMENT

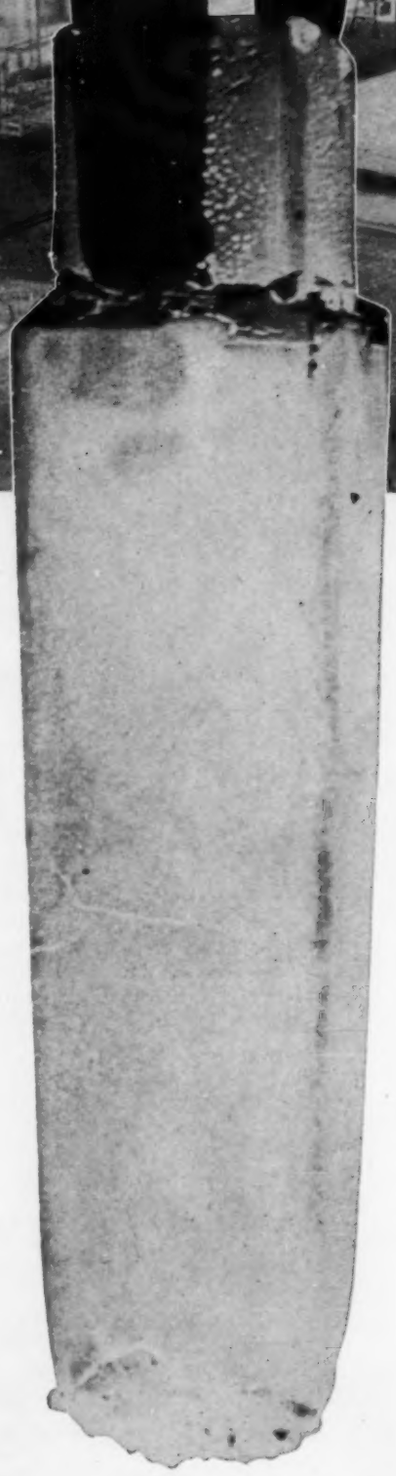
PATENTING, GALVANIZING AND TINNING TAKE-UP FRAMES
WIRE FLATTENING MILLS — SPOOLERS
NAIL GALVANIZING AND BLUEING MACHINES
BARBED WIRE AND FIELD FENCE MACHINES

WEAN EQUIPMENT CORPORATION

CLEVELAND • OHIO

No. 1155
Field Fence
Machine





Here's an absolutely unretouched photo—observe the results.

THE SALEM CIRCULAR SOAKING PIT

The circular shape of the pit makes charging and ingot positioning a very simple process. It also makes possible easy identification of the various ingots of a given heat within the pit. High tonnages under cover can be obtained over a wide range of ingot sizes and shapes without encroachment on combustion space. Regardless of the number of ingots placed in a pit, all ingots are located at a uniform distance from the source of heat.

From this standpoint alone, it is apparent why "The Salem Circular Pit" delivers the most uniformly heated ingots.

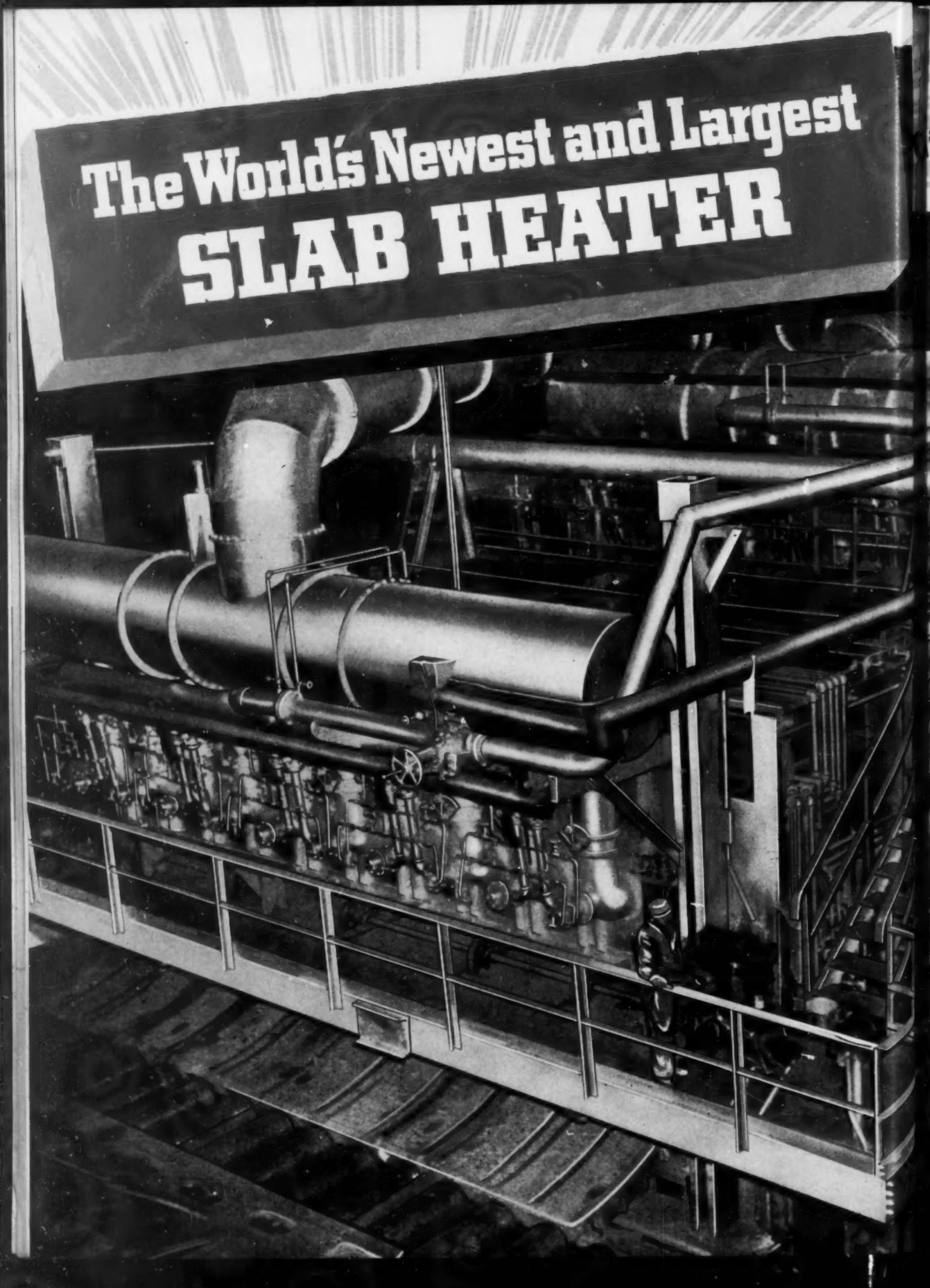
SALEM ENGINEERING CO. · SALEM, OHIO
SOUTHWEST OFFICE · FORT WORTH, TEXAS
SALEM ENGINEERING CO., (Canada) Ltd., TORONTO
SALEM ENGINEERING CO., Ltd., SHEFFIELD, ENGLAND

SALEM

ALL OFFICES STAFFED FOR . . . ENGINEERING, CONSTRUCTION and OPERATION

Salem Builds

CIRCULAR SOAKING PITS — CAR BOTTOM FURNACES — NEEDLE METALLIC RECUPERATORS
ROTARY HEARTH FURNACES — FORGE FURNACES — AIR RECIRCULATING FURNACES
CONTINUOUS BUTT-WELD FURNACES — HEAT TREATING FURNACES — GAS ATMOSPHERE FURNACES
MECHANICAL EQUIPMENT FOR CHARGING AND DISCHARGING MATERIAL FROM FURNACES


The World's Newest and Largest
SLAB HEATER

iant Slabs of Steel, Weighing Over 3 Tons Each are, Heated at a Production Rate up to 280,000 Pounds per Hour.

IN the initial processing of coiled strip steel, used for tin plating, huge steel slabs, 150 in. x 42 in. x 5½ in., and weighing approximately 9800 pounds each, emerge from this Surface Combustion Slab Heating Furnace, the newest and largest in the world, installed in the plant of Weirton Steel Company, Weirton, W. Va.

This furnace is 94' 9" in length and the width is 28' 0". It is of the recuperative type and has a "Tripled-Fired" burner arrangement of Surface Combustion design.

Here is another outstanding example of 'Surface' engineering, manufacturing and installation of modern heating and heat treating equipment in the steel producing industry. Other equipment includes One-Way Fired Soaking Pits—Billet Reheating Furnaces—Continuous Heat Treating Furnaces for Plate—Pit Type Convection Furnace for Annealing Rod Wire and Strip in coils—Continuous Strip Annealers and Normalizers—High Alloy Rod and Bar, Atmosphere Annealing Furnaces of Car-Bottom, Lift-Cover Type—Bright Annealing and Normalizing Furnaces for Tubing—Stress Relief Furnaces—Wire Patenting Furnaces—Annealing Covers, and the foremost equipment in Prepared Gas Atmosphere Generators for practically every heat treating operation.

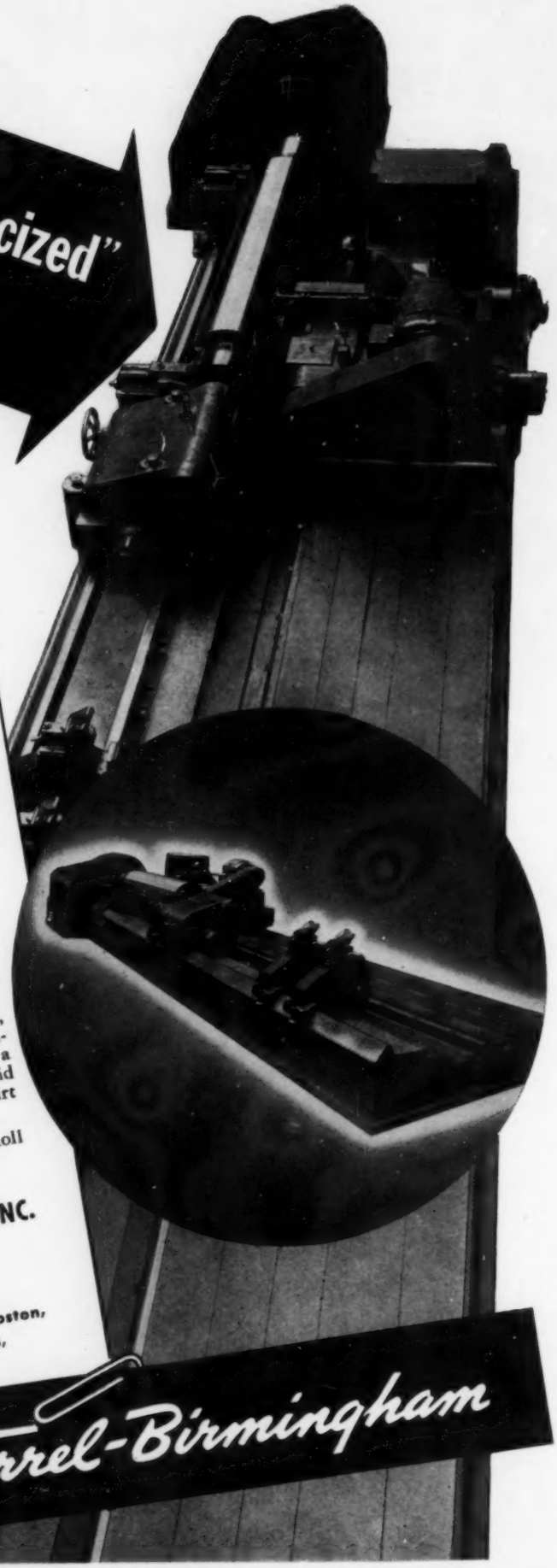
We will welcome the opportunity of working with you on your heating and heat treating problems.

'Surface'

SURFACE COMBUSTION CORPORATION

TOLEDO 1, OHIO

This roll is being "accuracized" on a Farrel 60" Grinder



With the Farrel Type HD, Heavy Duty Roll Grinder it is a simple matter to grind rolls to required accuracy and finish. The more important design features that contribute to *automatic precision* include:

AUTOMATIC CROWNING AND CONCAVING DEVICE—This built-in "brain" automatically produces a mathematically accurate curve for either a crowned or concaved roll, with both halves perfectly symmetrical. The same setting invariably produces exactly the same curvature.

GRINDING WHEEL SPINDLE—Of large diameter for rigidity under working load—made of high grade alloy steel, heat-treated and precision ground—mounted in adjustable bearings, automatically lubricated.

WHEEL SPINDLE AND HEADSTOCK DRIVES—Work and wheel are both driven through multiple V belts. Their smooth, vibrationless transmission of power safeguards precision.

TWO DEAD CENTERS—Dead centers in both headstock and footstock insure concentric rotation of the work, which contributes to precision grinding of journals and bodies.

INVERTED V WAYS—Cast separately from the bed, of a special grade of alloy iron, they are exceptionally resistant to wear, maintaining accuracy for a long life. Automatically pressure-lubricated and covered by flexible metal guards to exclude dirt and grit.

For the complete story of the Type HD Roll Grinder, send for descriptive bulletin.

FARREL-BIRMINGHAM COMPANY, INC.
ANSONIA, CONN.

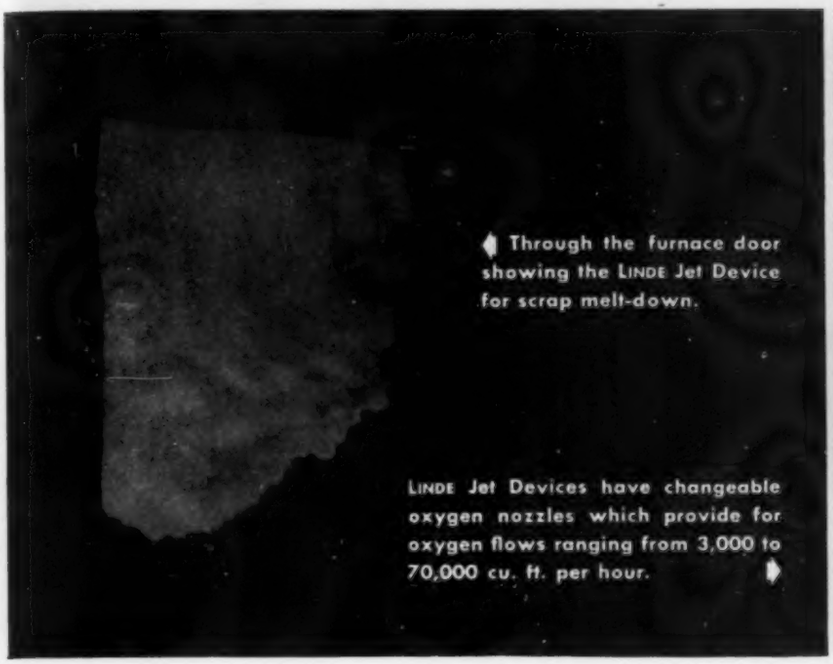
Plants: Ansonia and Derby, Conn., Buffalo, New York

Sales Offices: Ansonia, Buffalo, New York, Boston, Pittsburgh, Akron, Chicago, Los Angeles, Tulsa, Houston

Farrel-Birmingham

FB-404

What's the Story on Oxygen in Steel-Making Furnaces? No. 3 of a Series { No. 1 was a General Review / No. 2 was on Decarburization


Through the furnace door showing the LINDE Jet Device for scrap melt-down.
LINDE Jet Devices have changeable oxygen nozzles which provide for oxygen flows ranging from 3,000 to 70,000 cu. ft. per hour.

Mowing Down the Scrap

A JET OF OXYGEN AT SUPERSONIC VELOCITY directed against preheated scrap is used to rapidly cut down exposed portions of the scrap pile.

Data have been accumulated on the use of oxygen in more than 7,000 heats in 34 furnace shops with which LINDE has co-operated. When oxygen has been used for direct scrap melt-down, the time of the heat has been reduced appreciably.

The action of the oxygen stream on the preheated scrap is similar to oxygen-cutting. The heat of oxidation of a small amount of metal produces some superheated molten metal. Rapid melting of additional scrap is accomplished by highly efficient heat transfer. The oxygen jet is also used to clear a path for the main burner flame, and thus improve overall heat transfer.

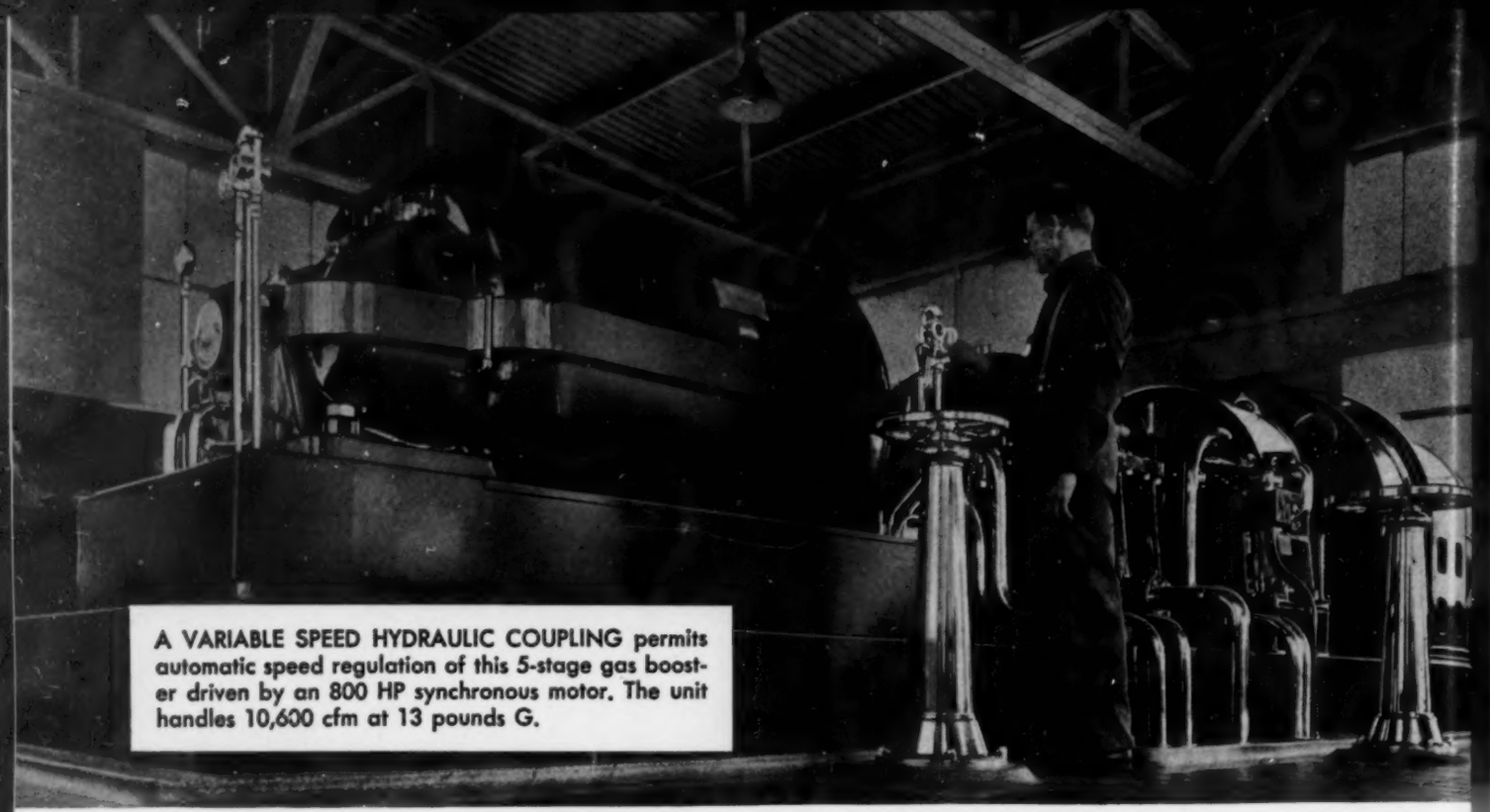
This method was a new idea that LINDE brought into the investigation of the use of oxygen in steel-making furnaces to increase output. The Jet Device, a water-cooled tool conceived and built by LINDE, is used. Oxygen consumption in experiments has averaged only 70 to 100 cu. ft. per ton of charge. Also, the operating time is short, especially in view of the results obtained—only 10 to 30 minutes. This method of direct scrap melt-down warrants thorough examination by the steel industry.

Management and production executives are invited to write for a copy of the factual report which LINDE has prepared on oxygen use in steel-making furnaces. This report also explains the DRIOX high-purity liquid oxygen system and LINDE's work on low-purity gaseous oxygen. Please address Room 308, 30 East 42nd Street, New York 17, N. Y.

Linde
Trade-Mark

THE LINDE AIR PRODUCTS COMPANY
Unit of Union Carbide and Carbon Corporation
30 E. 42nd St., New York 17, N. Y. UCC Offices in Other Principal Cities
In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto

The words "Linde" and "Driox" are registered trade-marks of The Linde Air Products Company



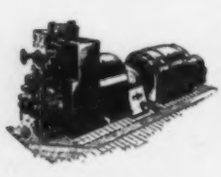
A VARIABLE SPEED HYDRAULIC COUPLING permits automatic speed regulation of this 5-stage gas booster driven by an 800 HP synchronous motor. The unit handles 10,600 cfm at 13 pounds G.

HOW TO GIVE PROFITS

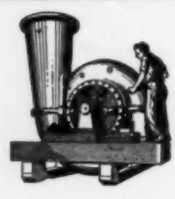
Use Newest, Efficient Allis-Chalmers Centrifugal Exhausters...Boosters in Your Modern Coke Plant!

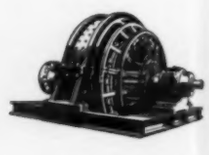
BY ACCURATE CONTROL of driven speed, *exhausters* aid in maintaining constant pressure in coke ovens, as well as in gas collector mains — assuring maximum by-product yield. Similarly, through automatic speed regulation, *boosters* transport gas from storage for further processing, or use, at constant pressure. Both centrifugal blower applications contribute materially to *efficient* coke plant operation — add to profits.

A-C BUILDS BOTH BLOWER AND DRIVE
This means a "team" designed for maximum efficiency and backed by a *single* responsibility.

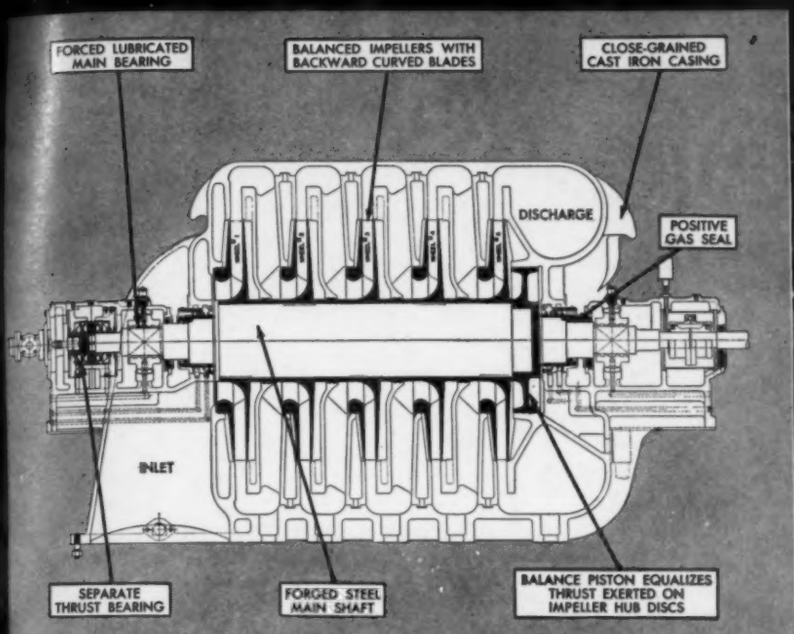


POWER & ELECTRICAL — Steam Turbines, Condensers, Water Conditioning, Power Transformers, Switchgear, Unit Substations, Circuit Breakers...

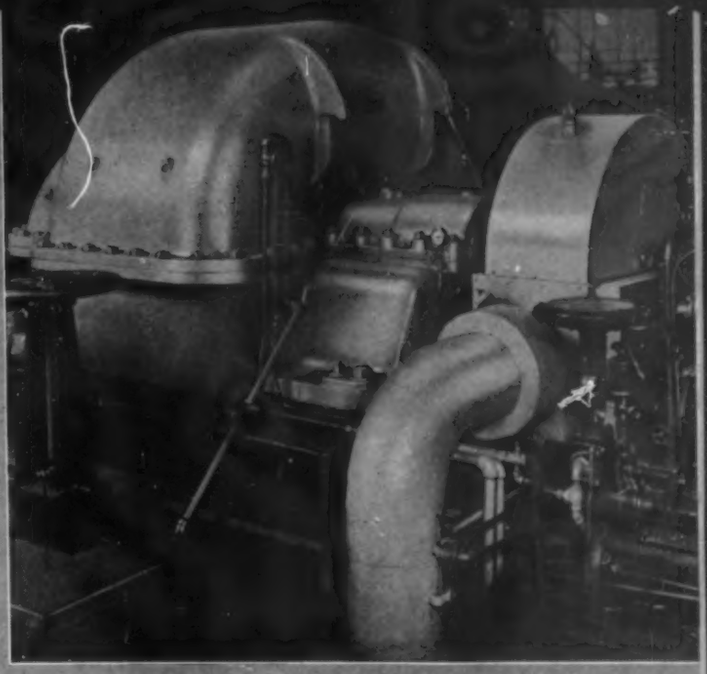




UTILIZATION & PROCESS — Motors, Blowers, Rectifiers, M-G Sets, Betatron, Pumps, Compressors, *Regulex* Exciters, *Texrope* V-Belt Drives . . .



CROSS-SECTION of a typical Allis-Chalmers centrifugal gas booster showing liberal design that means long life and low maintenance. Unit has five stages.



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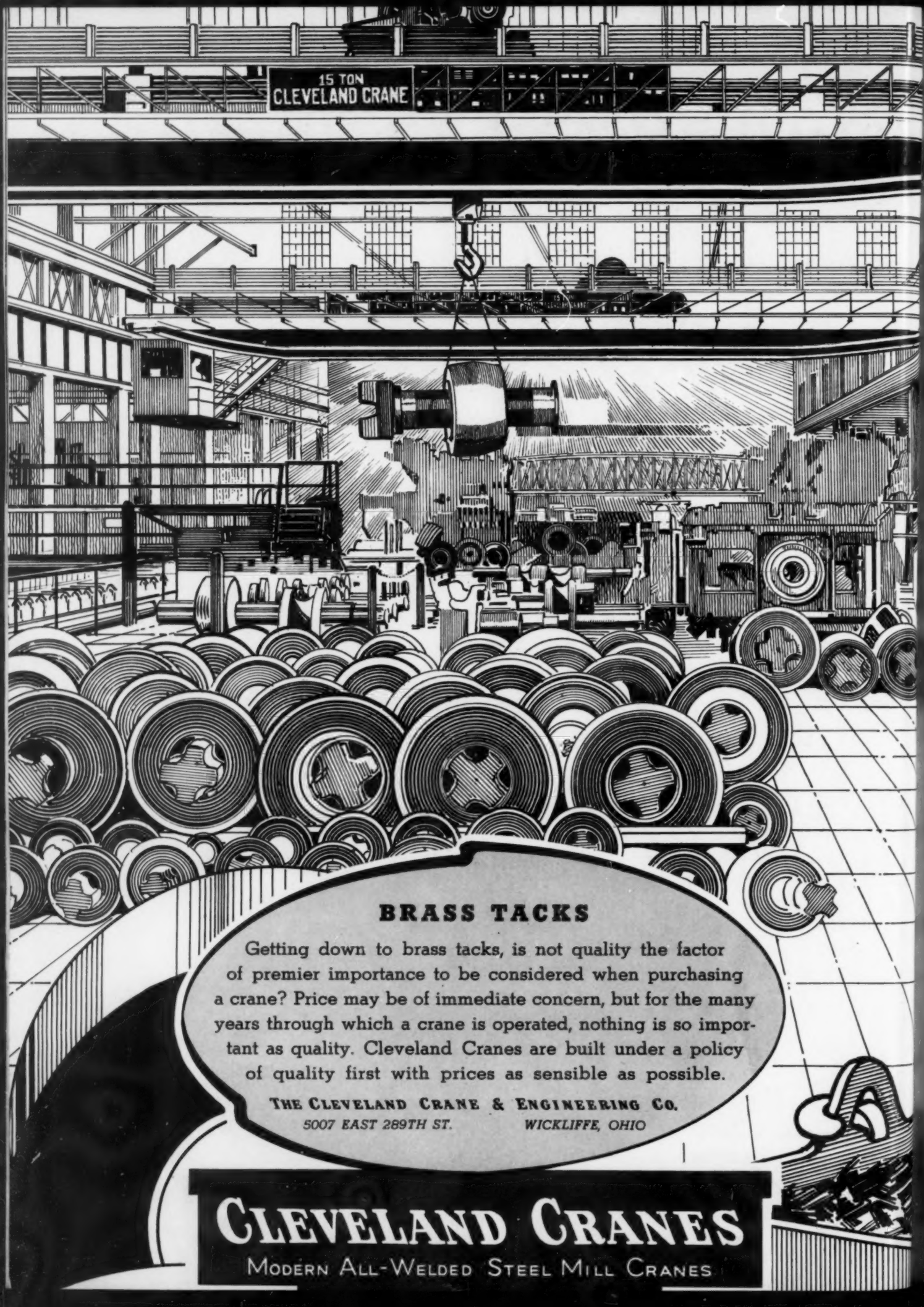

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MAINTENANCE and repair charges of the steel industry in 1946 totaled $490,000,000, according to the American Iron and Steel Institute. This is a decline of 9.6 per cent under the 1945 figure of $542,000,000, but is a new peacetime record.

Despite this decline, costs per ton of rolled products set a new record at $9.62 per ton, compared to $9.07 per ton in 1945 and $6.30 per ton in 1940.

▲

C. M. WHITE, president of Republic Steel Corporation said: "Steel is no monopoly. Anyone to whom the business looks attractive is perfectly free to enter it at any time. All he needs is assured sources of ore and coal, a good supply of nerve, and $200,000,000."

The line forms on the right.

▲

PERSONAL savings, which increased materially through the war years to reach a peak of 24.4 per cent of disposable income in 1944, has been gradually dropping, and amounted to only 6.7 per cent in the latter part of 1947.

▲

SECRETARY of the Treasury Snyder says: "Individual thrift and savings are America's most potent weapons against inflation and depression." Wonder why he limits it to "individual"?

▲

A FORMER divisional director of the governments general accounting office, T. Coleman Andrews, has informed a congressional committee that government bookkeeping is so confused that no one knows whether there was a surplus or a deficit last year. He reported that the supposed surplus ignored billions of dollars spent by various departments during the fiscal year but not reported until after the books were closed.

Maybe that's what makes the administration shy away from all suggestions of tax cuts.

▲

NEW additions of iron and steel products to lists under export control now place under restriction about 95 per cent of all exports of steel mill products to all destinations except Canada. Validated licenses are required for these exports.

THE 1947 lake season saw ore movements of nearly 78,000,000 tons. Although this is a peacetime record, operators fear some shortage before next season opens. They expect a carryover of only 7,000,000 or 8,000,000 tons of all grades by May 1, 1948. This amount, the lowest carryover ever experienced, is about one-half of the previous low.

▲

AN added editorial service is introduced in this issue of the IRON AND STEEL ENGINEER. On page 153 will be found a digest of day-to-day news items covering happenings in the steel and equipment industries, as well as items of general business and political news that may affect these industries. This feature is designed for busy engineers who must keep informed while they run. We hope that it will be of service to them.

▲

A SURVEY by Northwestern University indicates that engineers and others with technical training will be in greatest demand by major business and industrial firms. The next largest potential job category is in sales, and third place is held by special industrial jobs for which training is given after employment.

▲

HOPING that it does not sound like a phonograph record stuck in one groove, we again pass on the report of a new record payroll for the iron and steel industry. In October, payroll totaled $180,090,000. The month showed an employment total of 619,600, with 528,200 of these paid on hourly, tonnage or piece rates. This group averaged $1.546 per hour for 40.6 hours per week.

▲

WHEN a man says he feels like a two-year-old, does he mean an egg or a horse?

▲

STATE department records indicate that Russia has allowed only one American to enter its country for every 88 Russians granted visas to the United States. In one year, 4427 Russians were given American visas, while approximately 50 Americans were permitted to enter the Soviet Union.

Some steel companies used to follow a similar policy in their interchange of plant visitors with other companies, but soon found themselves shut off from this flow of information and new ideas.

▲

FOOTBALL coaches are discussing the desirability of eliminating the point after touchdown. They may get away with this, but they'll have lots of objectors if they try to eliminate the pint after touchdown.

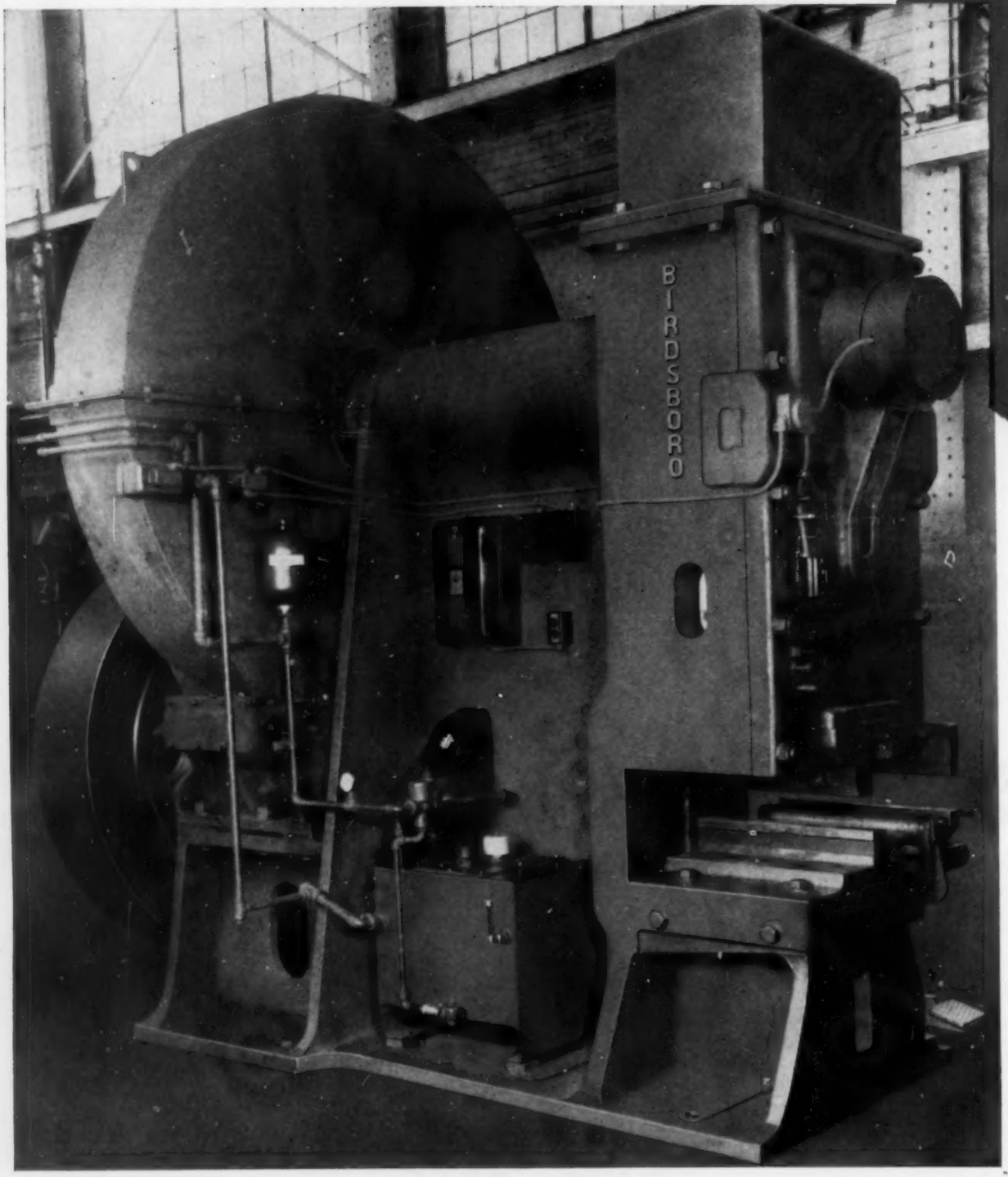
▲

NOT that we want to discourage advertising men, but Samuel Johnson, in 1859, said: "The trade of advertising is now so near perfection that it is not easy to propose any real improvements."

▲

ALL of us would probably be surprised if we knew how much our neighbors knew about us.

KEEP PRODUCTION LINES MOVING



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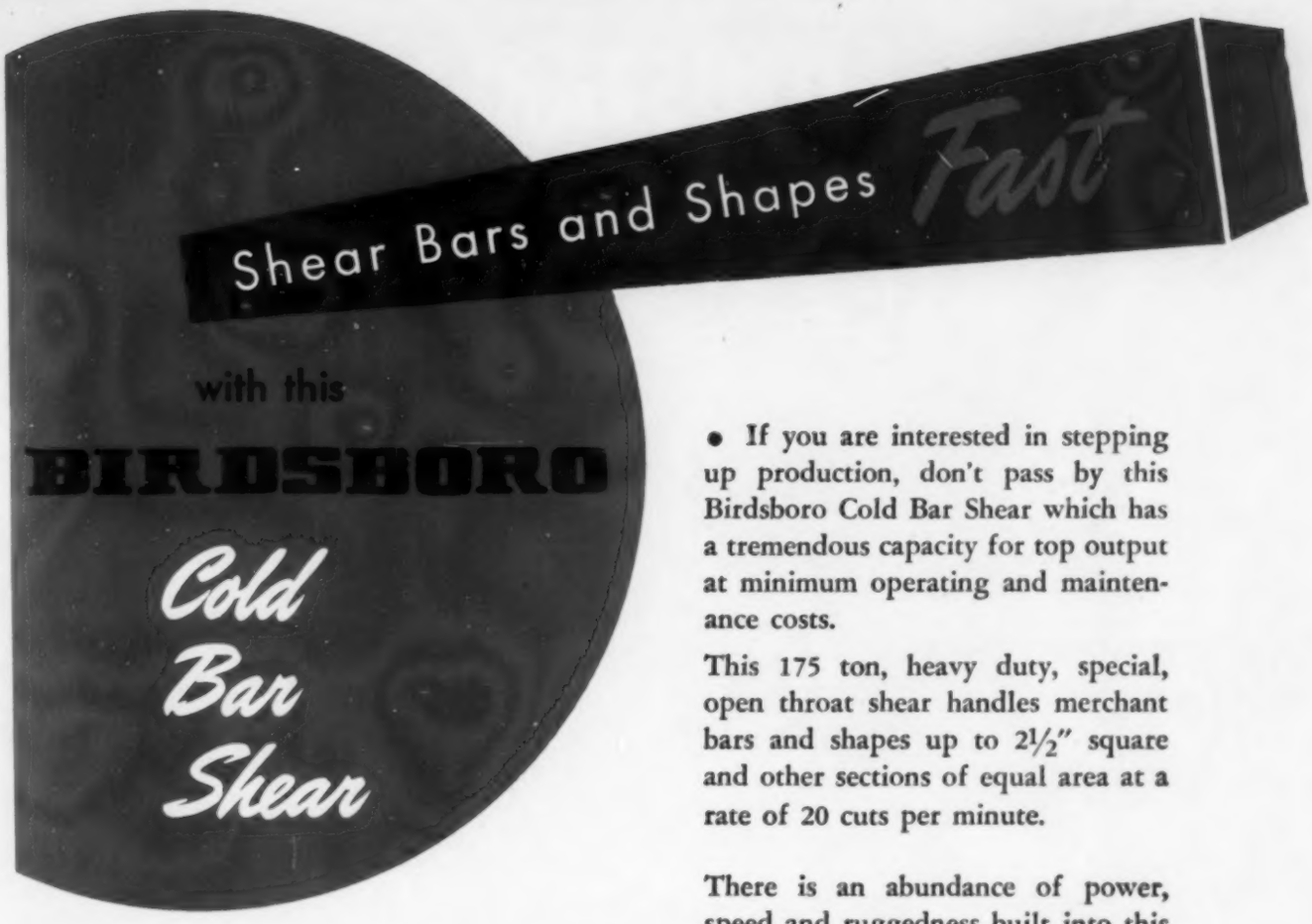

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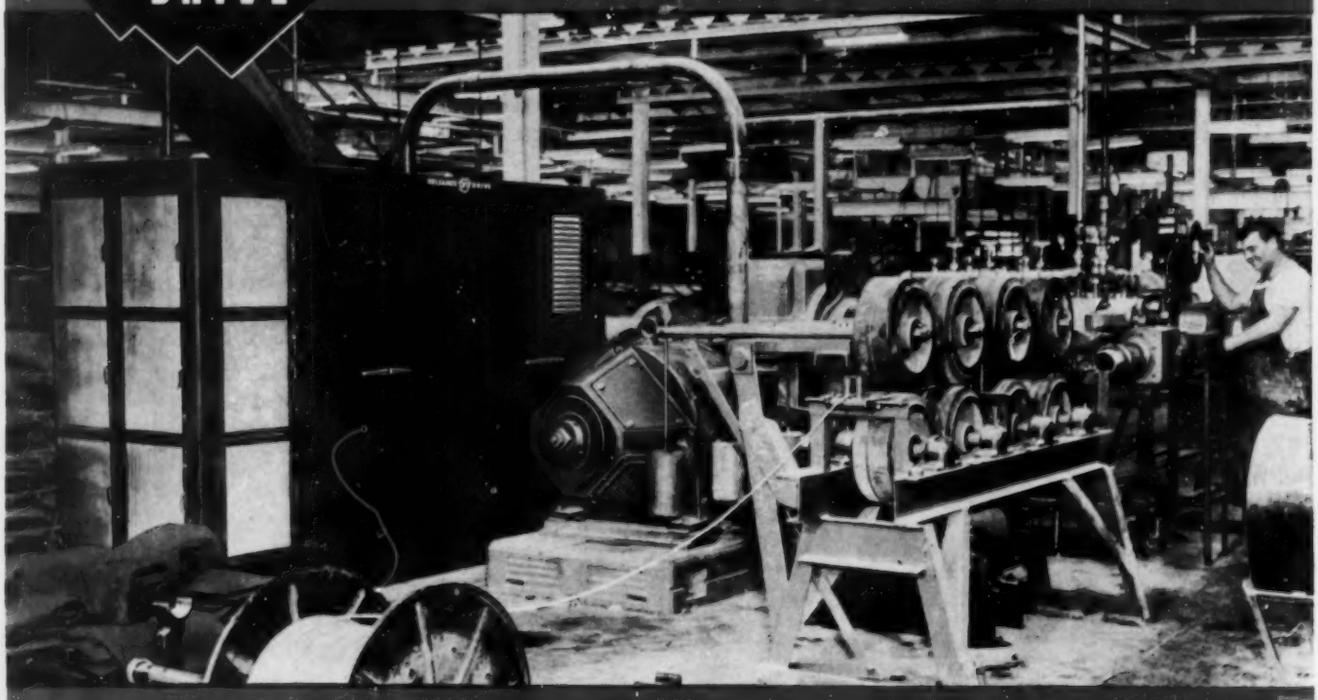

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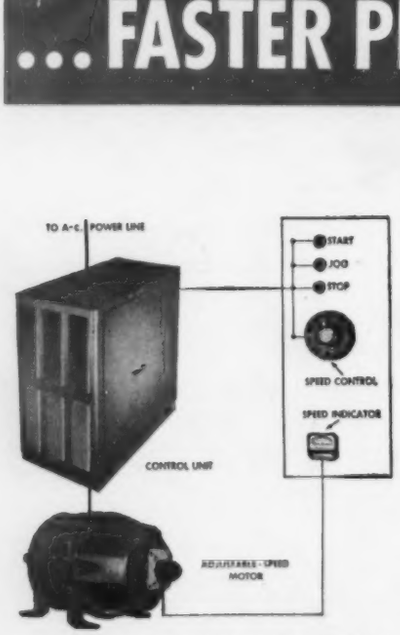

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Iron AND Steel ENGINEER

JANUARY, 1948 VOLUME XXV NUMBER 1

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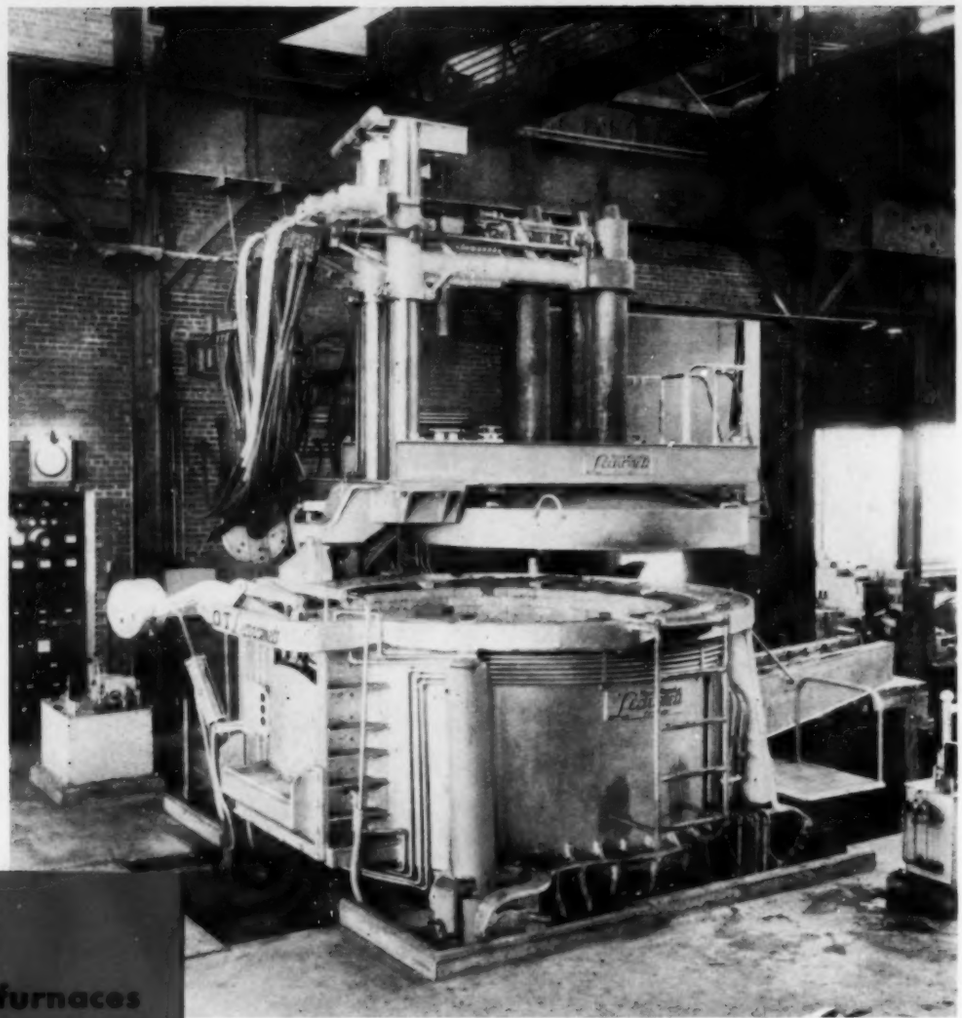

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Accelerating Carbon Elimination OF THE OPEN HEARTH BATH

. . . . oxygen use in the open hearth has been widely discussed in the past year, and most previous available information has been on the use of pure oxygen . . . . this paper describes test work done at one steel plant to determine the most economical concentration of oxygen for carbon reduction . . . .

By J. N. HORNAK

Assistant Division Superintendent

Open Hearth Department

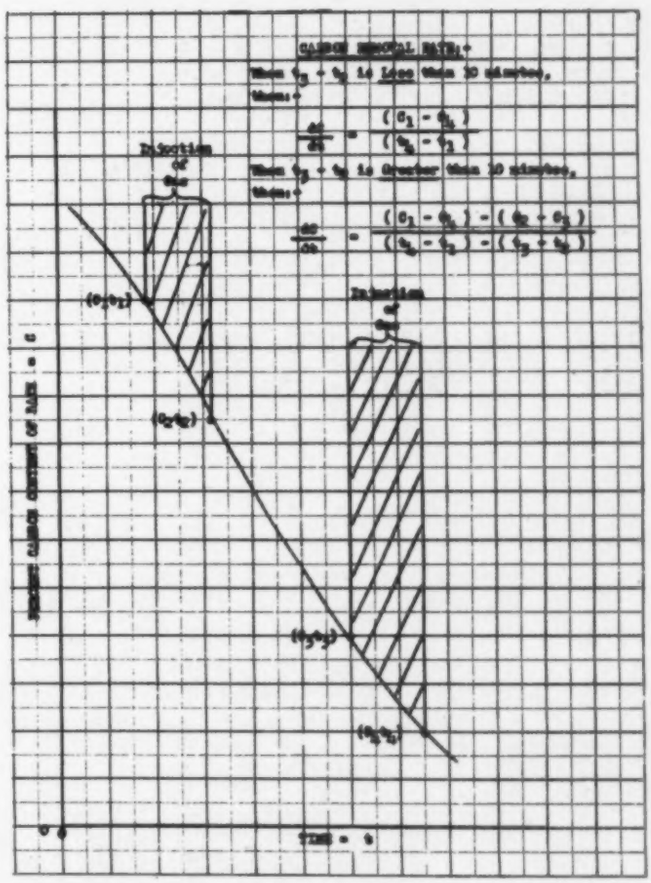
Carnegie-Illinois Steel Corporation

Homestead, Pennsylvania

▲ WITH the constant search for ways and means of increasing production, a number of basic open hearth operators at present are devoting considerable time to the development of the use of oxygen. This use of oxygen is two-fold, the first being for combustion air enrichment to accelerate the melting of the scrap and the second for metallurgical reasons, injecting it into the bath to accelerate the rate of carbon elimination during the working period. Several excellent papers on these two developments have already been presented, and it is not intended that this presentation should repeat what has already been given. This paper covers the metallurgical use of not only pure oxygen, but also other oxygen-nitrogen mixtures for accelerating the rate of carbon elimination by agitating the bath during the working period.

In November of 1946, the Homestead works of the Carnegie-Illinois Steel Corporation, in conjunction with the Linde Air Products Company, undertook a study of the metallurgical use of pure oxygen. The first group of twenty heats made were used to develop a technique of injecting the gas into the bath and also to gain some experience as to the resulting reactions of the bath. Following this group, a test run was made on consecutive heats over a two week period under as nearly normal operating conditions as possible. The results of this test run were very encouraging from a production standpoint, but it was impossible to determine the economy of the operation, because such factors as the effect of blowing on the furnace refractory life, furnace efficiency, type of agitating gas used, etc., had not been determined. Regarding the type of agitating gas, the question was raised at this time as to whether it was necessary to use pure oxygen or would a gas of lower oxygen content be satisfactory. The thought behind the word satisfactory was that although the rate of carbon elimination might be lower when using lower

Figure 1 — The effect of interruptions in gas injection were taken into account in the calculations.



Presented before AISE Annual Convention, Pittsburgh, Pennsylvania, September 23, 1947

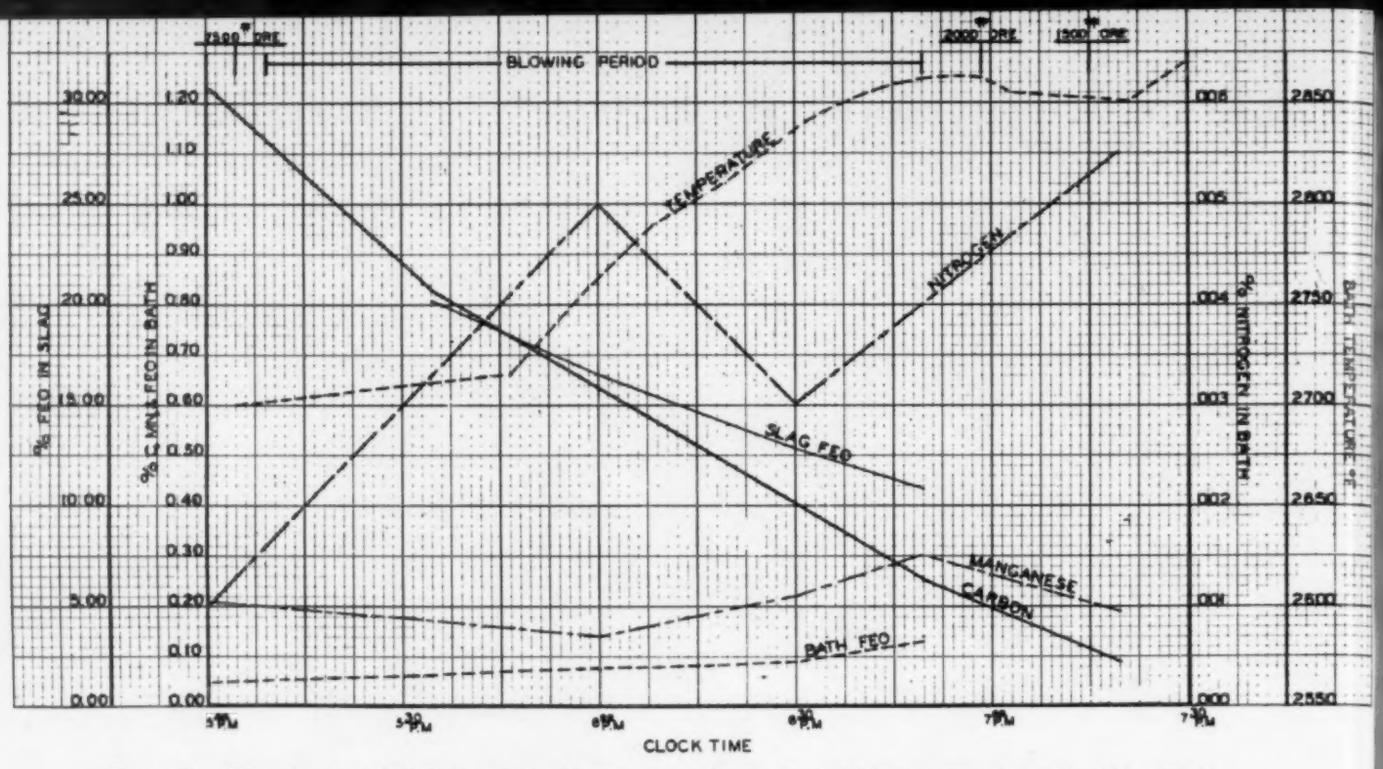


Figure 2 — The characteristics of a heat blown with 100 per cent nitrogen are shown in this graph.

oxygen purity gases, the difference in cost of the cheaper gas would justify its use.

As a result, in addition to the pure oxygen, the other gases experimented with were, namely:

1. 90 per cent oxygen.
2. 70 per cent oxygen.
3. 44 per cent oxygen.
4. 20.8 per cent oxygen — synthetic air (dry).
5. Compressed air (regular).
6. Nitrogen.

EXPERIMENTAL DATA

In order that the data from heat to heat would be comparable it was decided:

1. To make all the experimental heats in the same furnace.
2. To make all the heats to the same chemical specification.
3. As nearly as possible to follow the same working and charging practices.

It was found, during the initial group of heats, that the lance, from an operating standpoint, was the simplest tool to use for injecting the gas into the bath, and for this reason was used throughout the study. This does not mean that the lance is the only recommended means of injecting a gas into the bath as several other methods are being investigated at the present time.

The gas injection was started after the lime boil had partially subsided, and after an ore, limestone, or ore and limestone addition had been made to the bath. The rate of fuel input into the furnace was regulated by the first helper, who at all times aimed to maintain a bath temperature which avoided skulls, refractory failure or excessive temperature of the metal of the bath; also, standard furnace operation was employed with respect to draft control and furnace reversals.

In conducting these tests, the flow of the gas being injected into the bath was, on occasion, unavoidably interrupted for various reasons, such as excessive delay in replacing lances, attainment of excessive bath temperatures, etc. These interruptions if not taken into consideration affected the carbon elimination rate figure reported. In this report, the rate of carbon elimination is reported as shown in Figure 1. This procedure was followed to make the results comparable from heat to heat as it was felt that if the total carbon drop was credited to the time of gas injection, a false high rate would be reported when excessive interruptions occurred.

DISCUSSION OF DATA

Figure 2 is a chart of the working period of a blown or agitated heat and although nitrogen was used, it is typical or representative of those obtained with the other gases. Some of the items on this chart pertinent to the agitation of the bath are: (1) the effect on the nitrogen content of the steel, (2) the effect on the residual manganese, and (3) the temperature of the metal.

On heats worked with lime and ore, the average nitrogen residual is 0.004 per cent. This same average residual was also found on the heats agitated with gas, with the exception of 70 per cent oxygen and pure nitrogen, where residuals of 0.005 per cent and 0.006 per cent respectively were obtained. Although thus far this increase in nitrogen has not been found to be detrimental to the steel quality, it is intended to continue this part of the study.

The residual manganese curve is interesting in that normally when a heat is blown with any of the oxygen bearing gases, the residual falls off as the tapping carbon is approached, generally finishing below 0.10 per cent when 0.08 per cent carbon is reached. In the case of

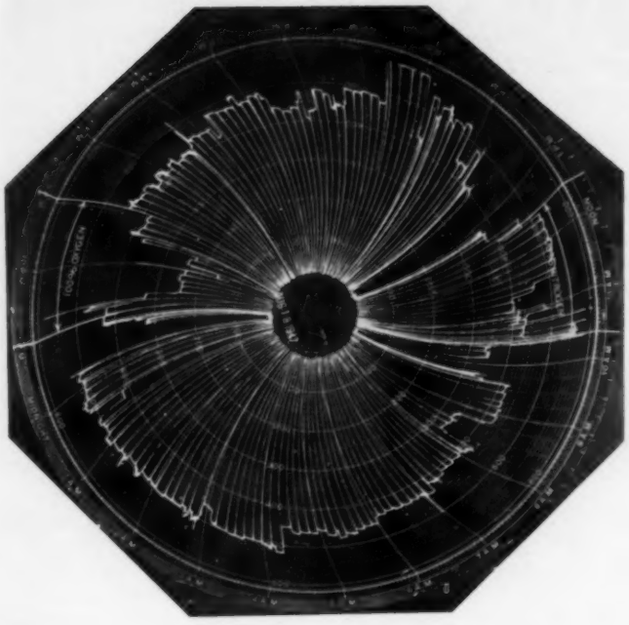


Figure 3 — As shown by this chart, fuel input for the heat blown with 100 per cent oxygen is less than that for the heat blown with 100 per cent nitrogen.

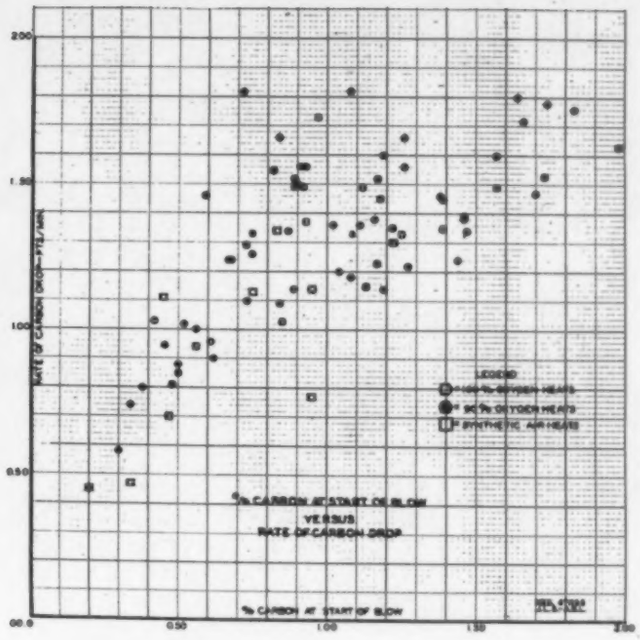
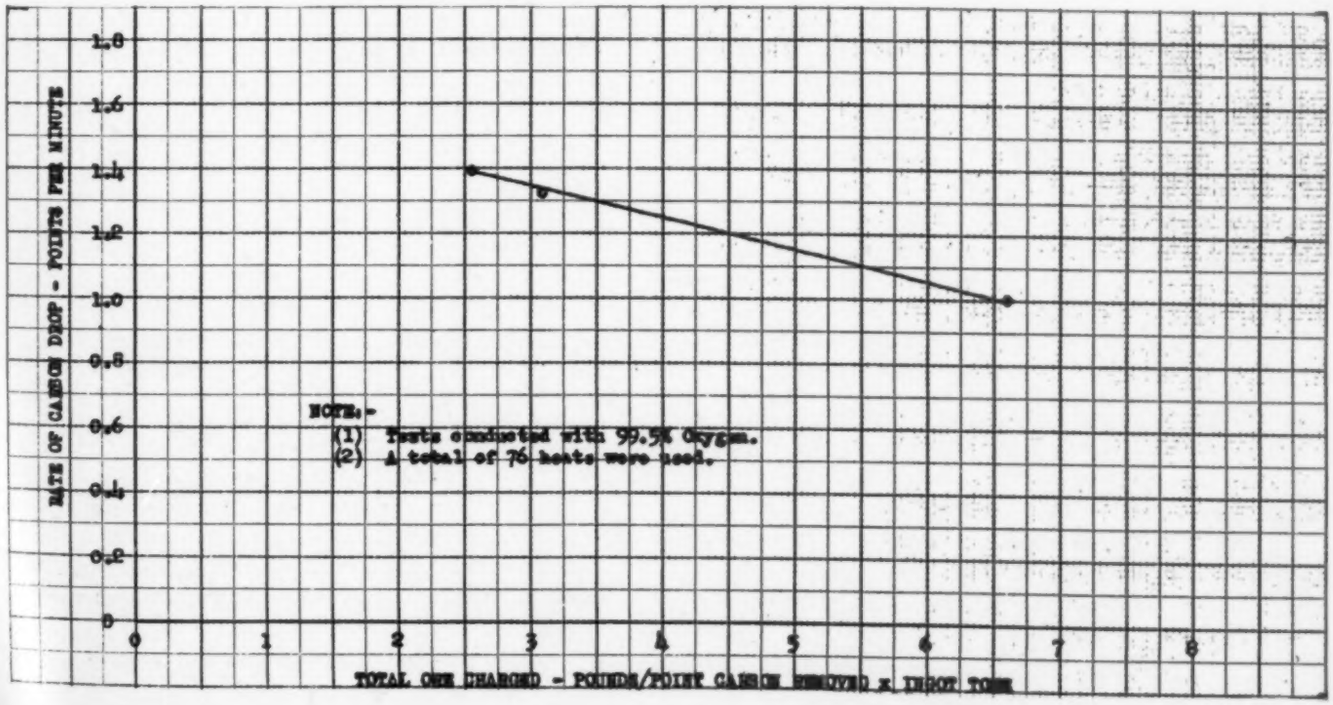


Figure 4 — There is a good bit of scatter in the rate of carbon drop for the same melt carbon range.

pure nitrogen, however, there is a reversion of the manganese from the slag to the metal and, with this reversion of manganese, the FeO of the metal increases less rapidly than normally. This may be a pertinent item toward steel cleanliness.

The bath temperatures reported were taken by means of an immersion pyrometer and the curve shows the desired gradual increase from melt to tap. The operator checked the pyrometer readings against furnace conditions and then either increased or decreased his fuel input as required. Figure 3 shows a representative fuel input chart. On this particular day, two heats were blown, the first with nitrogen and the second with 99.5 per cent oxygen. In the nitrogen heat, the rate of fuel input was increased to maintain a desired bath temperature, while in the case of 99.5 per cent oxygen, a considerable decrease was made to avoid overheating of the bath. This fuel reduction results in a savings that favors the use of high purity oxygen gases. An attempt has been made to keep a full head of fuel going into the furnace by adding ore or limestone to the bath during the blowing period to absorb some of the heat generated. So far, however, this addition has only made it possible

Figure 5 — Effect of charged ore upon rate of carbon removal.



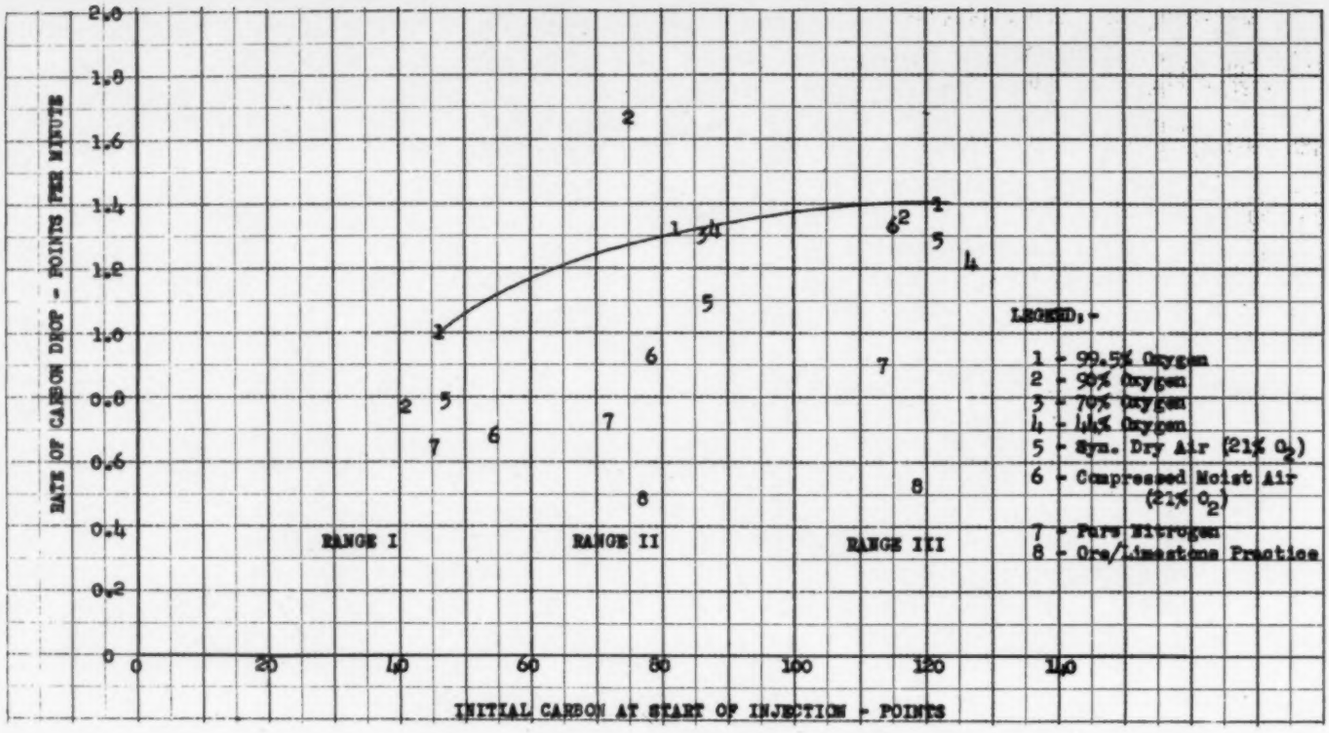


Figure 6 — As might be expected, rate of carbon drop increases as the concentration of the initial carbon is increased.

to complete blowing once it is started without interruptions.

Although there was in some cases considerable variation of the data from heat to heat, there was a fairly good correlation of the averages of the various groups. Figure 4 shows a buck shot or scatter diagram of the rate of carbon drop for three of the gases used. As can be seen, there is considerable spread in the rate of carbon drop for the same melt carbon range; also the diagram shows that as the melt carbon or the carbon content of the bath at start of blow increases, the rate of carbon elimination also increases. For this reason, the final calculations as shown in Table I were divided into three melt carbon ranges. This table which is self-explanatory attempts to show the relative effect on the rate of carbon elimination and gas consumption of the various gases used, and also the results of a standard lime and ore heat.

For this presentation, only the working period of the heat is considered and, for this reason, references to tons per operating or melting hour were omitted. As mentioned earlier, an attempt was made to show the relative value of the various oxygen, nitrogen mixtures for bath agitation. The comparison is necessary as once the heat is melted, the cost of the agitating gas would have to be balanced against the rate of carbon elimination obtained by each.

As mentioned earlier, there was a correlation on the scatter diagram of Figure 4 between the rate of carbon elimination and the carbon content of the bath at the start of blowing. This is further verified in Figure 5 on heats blown with 99.5 per cent pure oxygen where the rate of carbon drop is plotted against the total ore charged. This merely shows that for the same pig percentage, as the ore charged is increased and the heats melt lower, the rate of carbon elimination is also lower. In reducing the pounds of ore charged, there is a fuel savings in that there is less cold material to melt in the furnace.

The rate of carbon removal for the various carbon ranges selected is shown diagramatically in Figure 6. On this curve, the average rate of carbon removal for each of the gases in each carbon range is plotted against the carbon content of the bath at the start of blow. This curve shows that as the carbon content at start of blow decreases, the rate of carbon elimination is reduced. In addition, this curve also shows that as the oxygen purity of the gas is reduced, the rate of carbon elimination is likewise reduced. There are a few points on the curve that do not follow this trend, however, it is felt that these irregular points are due entirely to the limited number of heats in the group and that if more heats were available, the points would fall in line. It was very interesting in analyzing the points on this curve to note the effect of merely agitating the bath with an inert gas such as nitrogen, in which case the rate of carbon elimination was increased over and above that obtained by normal working procedure where lime and ore are used. This is of great interest, because in the past the acceleration of the rate of carbon elimination has been credited to the reaction between oxygen of the gas being injected and the carbon of the bath. These results indicate that part of the oxidation of the carbon takes place by a more rapid intermingling of the steel of the bath and the iron oxide of the slag; also, the exposure of the steel to the highly oxidizing atmosphere of the furnace. These reactions take place when using nitrogen to the extent that the metal is oxidized at a slower rate than normal and also the oxygen content

TABLE I

Summary of Test Results for Various Methods of Bath Agitation

Range of carbon at start blow	100% Oxygen heats			90% Oxygen heats			70% Oxygen heats	44% Oxygen heats		20.8% Oxygen heats (Synthetic air)			20.8% Oxygen heats (Compressed air)			100% Nitrogen heats			Lime and ore	
	1.01% to 1.40%	0.61% to 1.00%	0.25% to 0.60%	1.01% to 1.40%	0.61% to 1.00%	0.25% to 0.60%	0.61% to 1.00%	1.01% to 1.40%	0.61% to 1.00%	1.01% to 1.40%	0.61% to 1.00%	0.25% to 0.60%	1.01% to 1.40%	0.61% to 1.00%	0.25% to 0.60%	1.01% to 1.40%	0.61% to 1.00%	0.25% to 0.60%	0.60% to 1.00%	1.00% to 1.40%
Number of heats	26	32	12	2	2	2	4	2	3	1	4	4	5	1	1	2	1	1	15	8
Nominal tons per heat	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225	225
Limestone charged/ton	132	127	126	142	142	142	116	128	117	142	100	110	115	128	128	112	112	112	127	142
Limestone fed/ton	3.6	1.7	1.1	8.9	.....	.....	.....	6.7	.....	.....	3.3	.....	2.7	.....	.....	.....	.....	.....	7.7	3.3
Ore charged/ton	289	233	257	240	253	207	209	202	202	213	272	252	150	238	142	202	173	202	209	176
Ore fed/ton	25.3	23.2	10.7	31.1	26.7	40.0	23.0	33.0	32.0	44.0	28.0	8.4	40.0	36.0	27.0	55.5	33.3	22.2	30.4	28.1
% Carbon at start blow	1.21	0.82	0.46	1.16	0.77	0.41	0.86	1.27	0.87	1.22	0.87	0.46	1.15	0.79	0.55	1.14	0.72	0.45	0.77	1.19
% Carbon at finish blow	0.08	0.09	0.08	0.10	0.24	0.05	0.09	0.13	0.08	0.08	0.12	0.07	0.09	0.13	0.07	0.18	0.14	0.11	0.10	0.20
Points of carbon removed during blow	113	74	39	106	53	36	77	114	79	114	75	39	106	66	48	96	58	34	67	99
Time of blow (minutes)	81	56	39	78	32	46	63	67	59	88	73	50	81	72	69	105	80	50	.....	.....
Points of carbon removed/minute	1.40	1.32	1.00	1.38	1.66	0.78	1.33	1.25	1.34	1.30	1.09	0.81	1.35	0.92	0.70	0.91	0.73	0.68	0.51	0.59
Pressure at valve	70	70	70	70	70	70	70	70	70	70	70	70	63	30-65	63	70	70	70	.....	.....
Cu ft gaseous material/heat	81300	56200	40800	72000	24000	39000	51800	88000	55000	78000	71000	45000	73000	56000	60000	86500	50000	28000	.....	.....
Cu ft gaseous material/minute	1010	1040	1070	900	730	830	860	960	930	890	990	920	900	780	870	825	630	560	.....	.....
Cu ft gaseous material/point C	730	780	1115	680	430	1070	670	770	700	680	930	1120	680	850	1250	905	860	820	.....	.....
Cu ft gaseous material/ton	360	250	180	320	107	175	230	390	245	350	315	200	325	250	265	385	220	125	.....	.....
Cu ft gaseous material/point C x tons	3.2	3.5	5.0	3.0	1.9	4.8	3.0	3.4	3.1	3.0	4.1	5.0	3.0	3.8	5.6	4.0	3.8	3.6	.....	.....
Cu ft oxygen/heat	81300	56200	40800	64800	21600	35100	36200	38700	24200	16400	14900	9450	15300	11750	12600	.....	.....	.....	.....	.....
Cu ft oxygen/minute	1010	1040	1070	810	657	750	600	420	410	185	210	195	190	165	185	.....	.....	.....	.....	.....
Cu ft oxygen/point C	730	780	1115	610	387	960	470	340	310	145	195	235	140	180	265	.....	.....	.....	.....	.....
Cu ft oxygen/ton	360	250	180	290	96	157	161	172	107	73	66	42	68	52	56	.....	.....	.....	.....	.....
Cu ft oxygen/point C x tons	3.2	3.5	5.0	2.7	1.7	4.3	2.1	1.5	1.4	0.6	0.9	1.1	0.6	0.8	1.2	.....	.....	.....	.....	.....
Nitrogen content of steel product — %	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.006	.....	.....	0.004	0.004

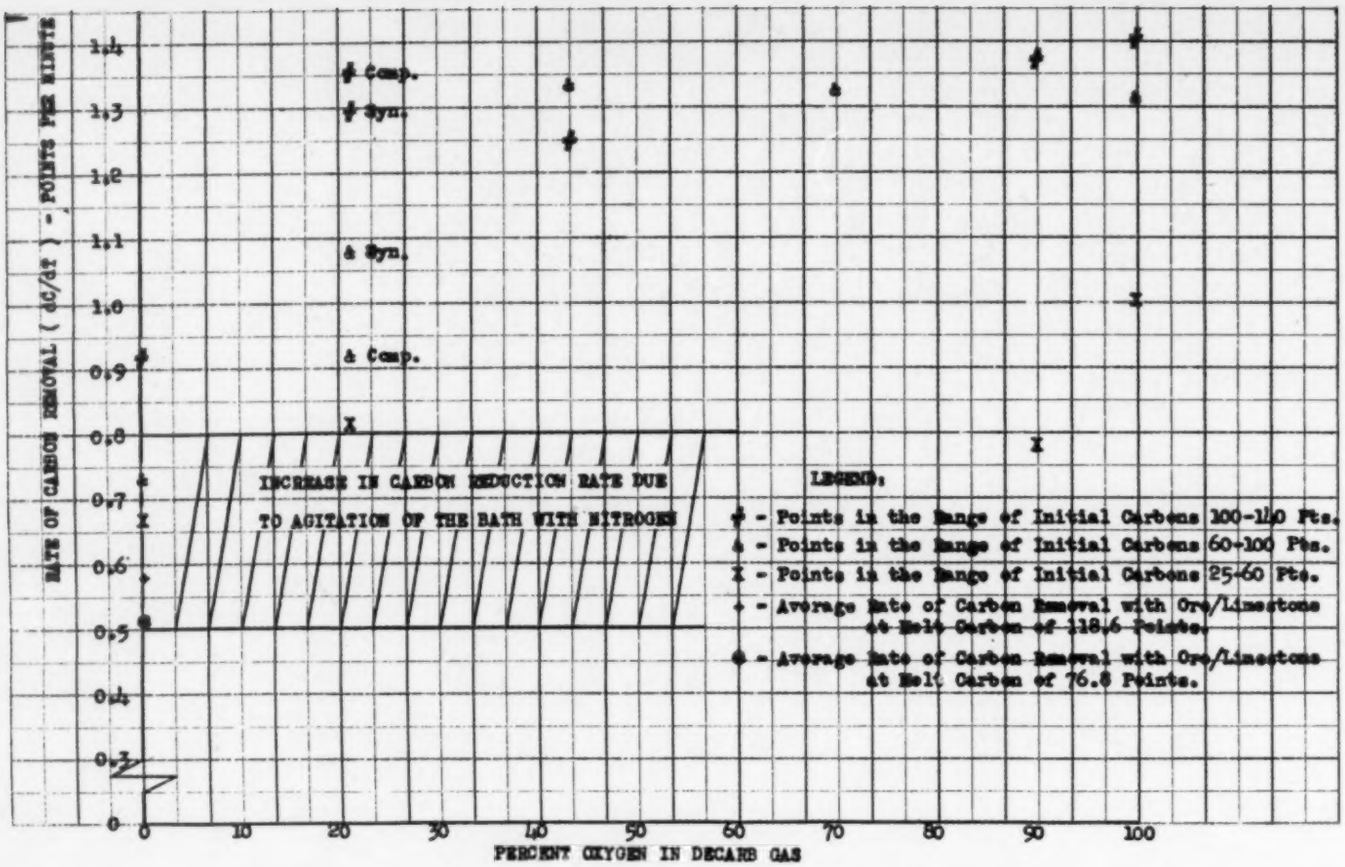
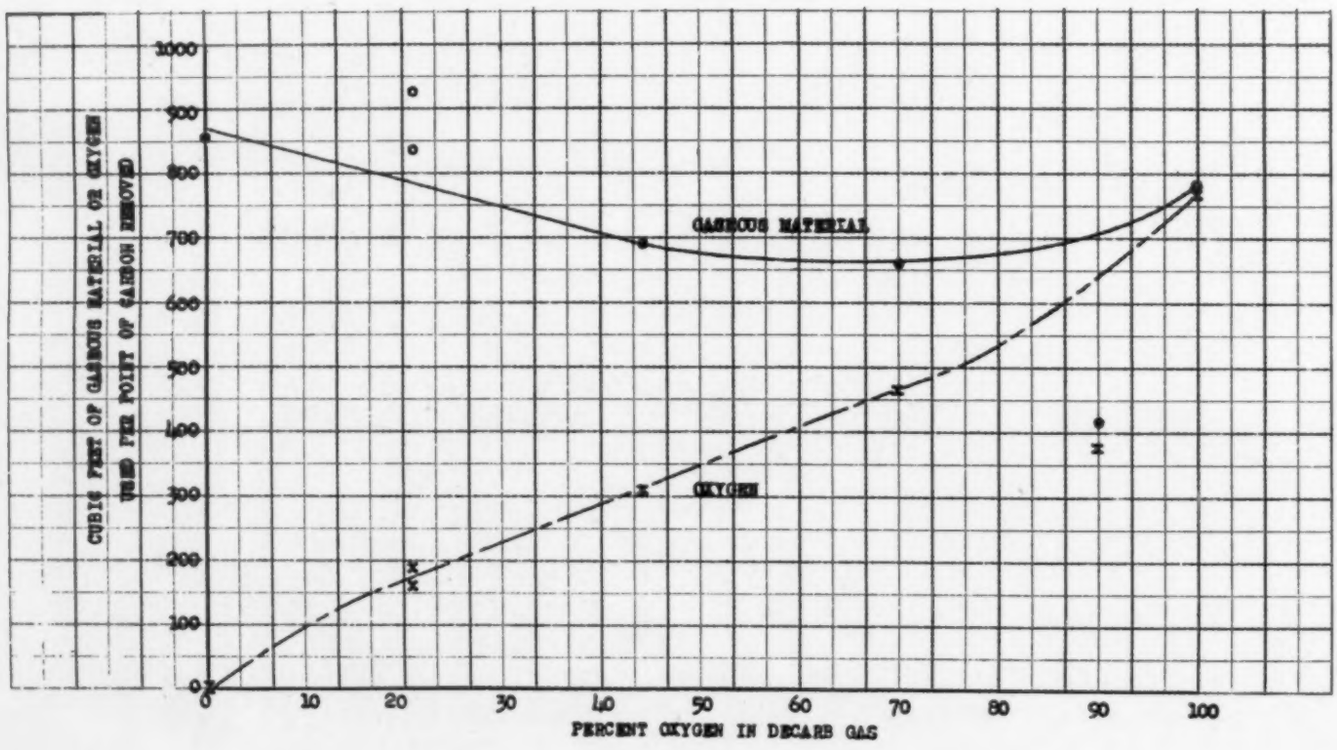

RATE OF CARBON REMOVAL (dc/dt) - POINTS PER MINUTE
PERCENT OXYGEN IN DECARB GAS
INCREASE IN CARBON REDUCTION RATE DUE
TO AGITATION OF THE BATH WITH NITROGEN
LEGEND:
- Points in the Range of Initial Carbons 100-140 Pts.
- Points in the Range of Initial Carbons 60-100 Pts.
- Points in the Range of Initial Carbons 25-60 Pts.
- Average Rate of Carbon Removal with Ore/Limestone at Heat Carbon of 118.6 Points.
- Average Rate of Carbon Removal with Ore/Limestone at Heat Carbon of 76.8 Points.

Figure 7 — Oxygen content of decarb gas versus rate of carbon removal.

Figure 8 — Increasing the content of the oxygen in the decarb gas increases the amount of oxygen used to remove a point of carbon.


CUBIC FEET OF GASEOUS MATERIAL OR OXYGEN USED PER POINT OF CARBON REMOVED
GASEOUS MATERIAL
OXYGEN
PERCENT OXYGEN IN DECARB GAS

of the slag is reduced with a reversion of manganese to the bath.

Figure 7 shows the same data in a slightly different form, the rate of carbon elimination being plotted against the oxygen content of the agitating gas used. This diagram shows the part of the total carbon elimination that takes place by the normal lime, ore, or lime and ore additions. The shaded area above is that part of the carbon elimination due to agitation alone. Above this are points that show the part of the total carbon elimination that can be credited to the oxygen content of the gas being used.

As for the gas and oxygen input or consumption per point of carbon elimination, Figure 8 shows diagrammatically the results for the different gases in the same carbon range. As the oxygen content of the agitating gas is reduced, the cubic feet of gas consumed per point of carbon eliminated increased slightly; however, the cubic feet of oxygen consumed per point of carbon elimination falls off at a very rapid rate.

CONCLUSIONS

The data show favorable increase in production rate by the gaseous agitation of the open hearth bath. In addition, the inspection reports of the finished product of heats that were agitated with the gas show that the steel from a quality standpoint was not adversely affected.

While these findings are favorable, there are several problems that must be solved or developed before the agitation of the bath can be adopted as a standard open hearth practice. One of these, and probably the most important, is the detrimental effect of the splashing of the slag and metal during the blowing period. This splashing, which with present practices reaches the brick work of the roof, has caused premature failure of this section of the furnace. Unless this problem is solved, which is partly a responsibility of the refractory people, the use of pure oxygen or oxygen-nitrogen mixtures may not justify themselves economically. The second major problem is one for the engineers and operators to solve or develop. This involves a suitable means of introducing the gas into the bath. The operation must be done in such a way that the charging of the adjacent furnaces is not interrupted, and the ideal condition would be such that when the time came for blowing or agitating the heat, the first helper on the furnace would merely have to move a few levers or valves and the operation could either be started or stopped. These are not all the problems, but they are two of the major problems encountered to date and it is felt that once these are solved, the others will be developed at a more rapid rate.

AIEE Winter Meeting Features

Mining and Steel

Headquarters for the AIEE winter meeting is the Hotel William Penn, Pittsburgh, Pennsylvania. Meeting will take place January 26-30, 1948, and members of the Association of Iron and Steel Engineers have received a cordial invitation to attend. Morning sessions start at 9:30 a.m., and afternoon sessions start at 2:00 p.m. except for inspection trips which are scheduled for 1:30 p.m.

Among the papers of particular interest to steel men are: Monday, January 26, 9:30 a.m.:

1. An X-Ray Thickness Gage for Hot-Strip Rolling Mills, C. W. Clapp, R. V. Pohl, General Electric Company.
2. X-Ray Thickness Gage for Cold Rolled Strip Steel, W. N. Lundahl, Westinghouse Electric Corporation.
3. Pin Hole Detectors for the Steel Industry, M. D. Bassett, L. U. C. Kelling, General Electric Company.

Tuesday, January 27, 9:30 a.m.:

1. Talk on Irvin Works of Carnegie-Illinois Steel Corporation to provide introduction to inspection trip, M. W. Reed, chief engineer, United States Steel Corporation.
2. Electric Equipment for Cold Strip Reduction Mills, W. E. Miller, General Electric Company.
3. WK^2 Aspect of High-Speed Mills, T. B. Montgomery, Allis-Chalmers Manufacturing Company.
4. Discussion on the Time Element in Speed Changes in Mills, C. R. Hanna, Westinghouse Electric Corporation.

Tuesday, January 27, 1:30 p.m.: Trip to Irvin Steel Works.

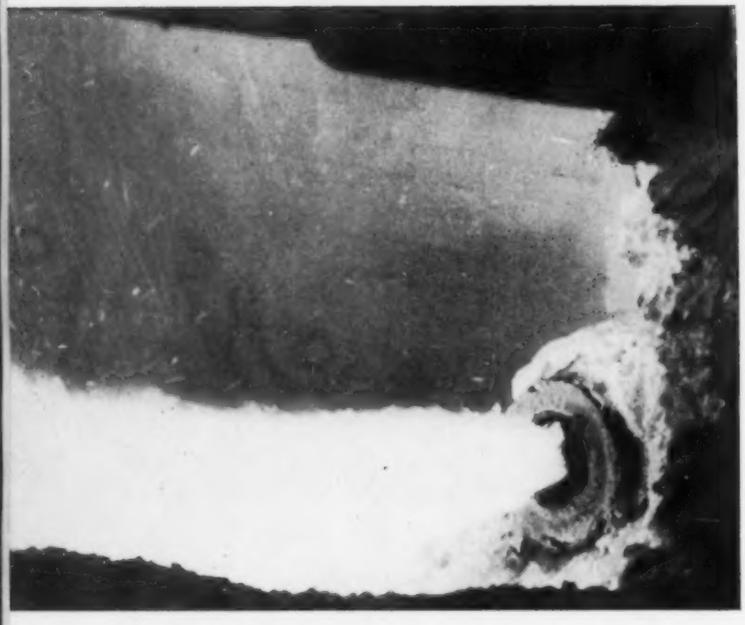
Members of the AISE will have their registration fee waived upon presentation of their AISE membership card.

DEVELOPMENTS

IN THE IRON AND STEEL INDUSTRY

DURING 1947

By I. E. MADSEN



Keynoting developments during 1947 was the large amount of work on the use of oxygen in steel plant production.

▲ THE unremitting demand for all types of steel, and the backlog of unsatisfied demand raised a question in the past year which will probably be debated for some years to come. "Is the steel capacity of the United States sufficient and adequate for national prosperity?" is a subject to which there is probably no unqualified answer. However, at the beginning of the year when the question was first raised, the reaction of the steel industry was that the demand was abnormal and unbalanced; that as soon as inventories were filled, wartime pent-up demand satisfied, and new facilities under construction completed, capacity would be more than ample to satisfy all requirements. As the year progressed, demand did not decrease except for some selected items, and it has recently been estimated that it may be several years before all deferred demand will be satisfied, provided industry operates at levels substantially equal to the present time.

Unfortunately also, the steel industry has been made the scapegoat for shortages of all types, whether applicable or not, the reasoning going as indicated in the following hypothetical case. Paper is short because lumber is short, because equipment for moving lumber is short, and in turn the equipment is short because of insufficient steel deliveries. Such reasoning, on the other hand, emphasizes how much the economy is dependent on the steel industry.

It has been unfortunate also that the industry has not received full publicity for all it is doing in increasing capacity and efficiency of operations. One can hardly point the finger at any company or plant which is not doing something towards adding new facilities, or adding capacity in certain departments to more fully utilize the capacity of the whole plant. Finally, the recent development work on such phases of steel production as the use of oxygen in the open hearth will, when all detail problems are ironed out, offer a decided increase in steel capacity more quickly than through the construction of new facilities, and much more economically in the use of scarce materials such as steel, copper, etc. One factor which has been often neglected by the proponents of the additional steel capacity program has been the loss in production due to strikes and labor disputes, and this lost production might possibly be the margin between satisfied and unsatisfied demand. Strikes represent a loss of 18,000,000 tons of steel ingots since the end of the war or more than 10 per cent of the actual output during that period. If this loss of tonnage, equal to 2½ months of production, had been averted, there would be far fewer complaints of steel supplies today.

Estimates on required capacity will vary with assumptions on the population increase and per capita demand. The latter figure in the period 1920-1940 varied from a high of 978 lb domestic demand in 1929 to a low of 236 lb in 1932 with an overall average for the 20 year period of 668 lb. If it is assumed that the population in 1955 is 148,000,000, and domestic and export requirements are 978 and 81 lb respectively, maximum consumption will be 78,464,000 tons of steel ingots which is only an 85.9 per cent rate of operations based on our present capacity of 91,241,250 tons. On the other hand, one of the last things which the Civilian Production Administration did before its liquidation was to report a finding that an additional 20,000,000 tons of ingot would be needed within the next two years. This figure

was based on a study of ratios between steel consumption level and the gross national product plus assumptions on the future of the gross national product. The Bureau of Labor Statistics in another study came to the following conclusion: With full employment, steel demands in 1950 would be between 98,000,000 and 120,000,000 tons.

It is understood that the President's Council of Economic Advisers is studying the steel supply demand situation and that its report, when it is issued, may form a basis for government action in getting behind a steel expansion program.

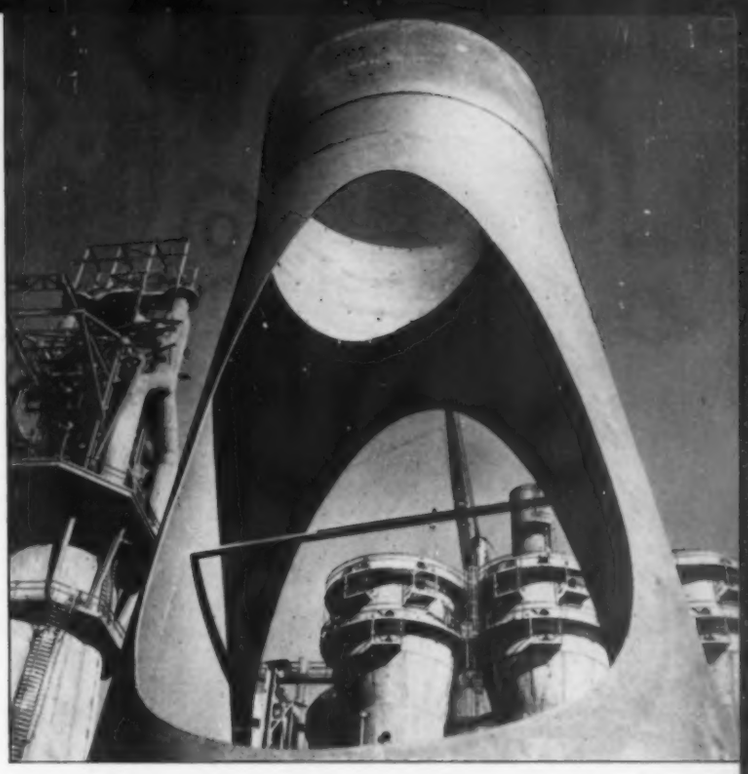
The postwar reconversion changed the distribution pattern of steel; the large scale users, during the war, such as ordnance and shipbuilding, were relegated to a relatively minor role as the automotive industry became the leading industrial outlet. This shift in demand was one of the factors in steel shortages and was a basic factor in determining the type of expansion which has been going on in the past year.

The latest figures on the scheduled increase in sheet strip capacity indicate that by the end of 1947, the net increase over July 1941 was about 2,000,000 net tons, the increase by July 1948 will be about 3,000,000 net tons and by the end of 1948, the increase over 1941 will be about 3,600,000 tons. Although the actual new installations represent an increase in potential capacity of about 4,000,000 tons in cold rolled sheet and strip, actual tonnage available is dependent on products manufactured and is also modified by the eventual discontinuance of production of hand mills, whose capacity is about 350,000 tons annually.

The sheet steel shortage is expected to last until about mid 1948. Cold rolled steel and galvanized steel are the two products which are in shortest supply.

One trend in the industry during the year has been the purchase, by many users of steel products, of the steel manufacturing facilities to make the products, particularly sheet and strip, that they normally purchased, and a number of the smaller mills were taken over by large steel users.

The latest of these purchases was that of the Empire Steel Corporation of Mansfield, Ohio, by the Studebaker Corporation. This company has an annual capacity of 348,000 tons of steel ingots and 120,000 tons of hot-rolled sheets. Other similar purchases occurred last year when the General Electric Company acquired the Mahoning Valley Steel Company; Kaiser-Frazer took over the Chapmanprice Division of the Continental Steel Corporation; the Struthers Furnace Company, and a working arrangement with the Portsmouth Steel Corporation; Borg-Warner Corporation acquired the Superior Sheet Steel Company; and the Barium Steel Corporation, which is a holding corporation for a number of manufacturing subsidiaries, took over the Central Iron and Steel Company. The International Detrola Corporation purchased the Andrews Steel Company; and a syndicate of twenty-five manufacturers bought the Apollo Steel Company and the Phoenix Iron Company. Three of the plants purchased are steel makers only, two are blast furnace plants, and eleven have rolling facilities with five of these making steel and one producing pig iron. Total ingot capacity of these plants is 2,250,000 net tons. These purchases reverse the general trend since World War I in which users divested



Typical of new construction is this blast furnace being built at South Chicago works of Carnegie-Illinois Steel Corporation. It is part of the U. S. Steel Corporation's $500 million expansion program.

themselves of steelmaking facilities, and indicate a new trend which may continue for some time. The result may be that other consumers, as long as steel is short, will find a more limited market in which to purchase their supplies.

At the beginning of the year about $448,000,000 were earmarked for expenditures for new equipment in 1947, and the bulk of this money was earmarked for expansion and modernization of the industry's facilities for producing sheet and strip. However, increases in the price level of all commodities made the $448,000,000 figure obsolete and at present prices this cost will be well in excess of half a billion dollars. As a matter of fact, the increase in cost may delay some projects until construction costs are more reasonable.

As an example of the increase, most of the existing capacity of the industry was installed at a cost of about $50 per ton whereas new capacity today is likely to cost about $200 per ton. This means that steel production from the new capacity would have to sell at least $20 per ton above current market prices if there is to be any return on the investment. Since the return on the investment in steel making has gone down from about 7 per cent at the beginning of the century to less than half that in recent years, financing of such additional capacity becomes an ever-increasing difficult problem. In addition, the revenue laws which limit depreciation based on original costs, make it much more difficult to replace obsolete facilities when new facilities are required. When one thinks that a complete economic integrated steel plant will cost about $250,000,000, the magnitude of the financing program can be well appreciated.

Many steel men doubt that the facilities, at present cost, can be operated profitably over a period of years. One steel company estimates that the facilities which

were added in 1946 at a cost of $27,000,000 are actually worth only $19,000,000 over the period in which they must be amortized, which means that about $8,000,000 consists of abnormal costs.

For large steel expansions, new raw material sources may have to be developed. Incidentally, any new fully integrated steel capacity which would be started now could not become fully effective before 1950. For every 10,000,000 tons of such new capacity, at least, 2,000,000 tons of steel must be taken out of existing allocations. Another trouble would be labor, for at the present time about 60,000,000 people have jobs, and more people are working than have ever done so before.

Additional ingot capacity now scheduled is running close to 3½ million tons. In addition there will be 3,000,000 tons of added coke oven capacity, 3,000,000 tons of blast furnace capacity, and 3,000,000 tons of added sheet and strip capacity. Much of this expansion however, will not be completed before 1948 and 1949. Some of the increased ingot capacity will be due to the use of oxygen in the open hearth.

More than half of the steel plants which were owned by the government have now been acquired by the steel industry and are now in operation.

The continued shortage of scrap is one of the reasons for the increase in the pig iron capacity, since the price of scrap as well as the difficulty of getting it makes it more economical to use a higher pig iron charge. The increase in pig iron capacity has also necessitated the additions and modernization of coke oven plants, and many plants are modernizing or adding additional batteries of coke oven capacity.

Other miscellaneous facilities which are being constructed include power plants, machine shop equipment, soaking pits, materials handling equipment, scrap preparation machinery, coal mine development equipment, ore mine development equipment, and ore sintering facilities.

Steelmaking capacity as of January 1, 1947 was 91,241,250 tons which was a very slight reduction over the capacity of 91,890,560 tons at the beginning of the previous year. The total blast furnace capacity at the beginning of 1947 was 65,709,200 tons compared with 67,340,590 tons the previous year. The reduction in both cases was due to the withdrawal of obsolete facilities from production. However, the expansion program discussed above will raise these figures. As an example of the expansion, the largest steel company in the country is spending $500,000,000 to increase by-product coke capacity 1,900,000 tons, pig iron capacity 1,000,000 tons, ingot capacity 300,000 tons, sheet capacity 925,000 tons, tin plate capacity 500,000 tons, tubular products 300,000 tons and wire products 80,000 tons. The second largest producer is increasing ingot capacity by 800,000 tons and flat rolled capacity by 2,000,000 tons with the work entailing an expenditure of $300,000,000.

Another steel company's expansion program will give an increase of 400,000 tons of ingots. Still another company is increasing its capacity by 800,000 tons in two plants and 500,000 tons of this increase are expected to be due to new oxygen plants.

Steel production in 1947 established new peace-time records and the production for the year totaled about 85,000,000 tons of ingots or about 93 per cent of capacity. This is ⅓ more steel than was produced in 1929, the peak year prior to 1940, and compares well with the all-time peak of 90,000,000 tons in 1944. Expansion of production beyond the level attained was limited by the difficulties of increasing the flow of raw materials to the mill. Scrap, pig iron and metallurgical coal were in short supply throughout 1947. Much of the scrap shortage was due to the more than 120,000,000 tons of scrap or potential scrap lost by the war. Iron production in 1947 was over 59,000,000 tons or about 90 per cent capacity.

Shipments of finished steel for 1947 were about ¼ higher than 1946 and amounted to approximately 62,000,000 net tons.

Steel can be produced without the use of scrap and the method in most use is by means of the bessemer converter. The production of this synthetic scrap has, however, been limited by the increase in pig iron production and also by bessemer capacity.

Studies are still going on and experimentation is still being done, particularly by the U. S. Bureau of Mines, on the production of sponge iron by the Krupp-Renn process. One report by the bureau states that their experiments "have shown that the Krupp-Renn process makes possible local reduction of ores too poor for blast furnaces in areas where it has not been previously practical."

The continued depletion of high-grade ores has been of increasing concern to the industry. Beneficiation of ores is continuing and as it becomes more common, large investments in plant and equipment may transform the mining regions around Lake Superior into what might be classed a manufacturing area. In 1946 about 12,000,000 tons of iron ore or 23 per cent of the Minnesota ore shipments consisted of concentrates from inferior ores and in 1947 such shipments were approximately 20,000,000 tons. Several companies have announced plans to construct large scale beneficiation plants in the Lake Superior district. These facilities, it is estimated, may cost as much as $500,000,000. The expenditures in the very immediate future are concentrated on research and construction of pilot plants for treating the ore, and one company is building two such plants at a cost of $2,000,000. Another company is planning a plant for the production of 2,500,000 tons of iron ore concentrates annually from taconite ore and it is estimated that such a plant will cost $15 for each ton of annual output. The most common treatment of lake ores now consists of crushing, screening, washing and separating according to sizes and density. Because the iron ore is hard and dense and the waste material is soft, separation is simple, but a considerable amount of fine iron ore particles is lost in the tailings.

One factor in the ore situation is the recent development work on the development of ore deposits in Labrador. According to latest figures available, it is estimated that there is a total of 260,000,000 tons of iron ore in this new development which ranges from 60 to 69 per cent or higher of Fe, thus making it one of the largest and richest deposits in the world today. This deposit is not being worked and it will take at least 3 to 4 years before production could begin. One item needed in the development is a railroad from the deposit to a port. The discussion on the development of this ore body has led some experts to believe that it

may be economical to establish steel plants on the Atlantic coast to take advantage of water-borne shipments of foreign ores such as the Labrador development direct to the plant. Some experts, on the other hand, do not agree that this would be an economical trend in the expansion of the steel industry.

Similarly, although limestone is one of the most common stones, the high-grade deposits of high-purity stone are not too numerous and are being mined at a rapid rate. Here again the industry is moving toward the usage of low-grade materials at higher costs.

The reserves of fuel, particularly coal, appear to be ample except for the highest grade coking coals. The gradual decrease in the requirements of coking coal per ton of iron from 3600 lb in 1918 to 2800 lb in 1941 is a real gain in the conservation of this natural resource.

The increasing mechanized handling of coal at the mines is also resulting in a raw coal which contains from 15 to 30 per cent of rocky refuse because of the inability of the cutting and loading machines to distinguish between coal and slate. Consequently, the coal industry is developing washing installations for washing and screening in order to reduce the ash content. The more elaborate preparation plants which will be required for the control of ash and sulphur content, as poorer grades of coal are used, will give rise to higher costs.

One interesting technique in the charging of coals into the coke plant has been the practice of mixing coal with oil to reduce the moisture content of coals entering the plant. This procedure has helped plant operations by maintaining more even flue temperatures, more evenly charged ovens, and has given a more uniform coke.

One interesting coal development in the year was the experiments which were conducted jointly by the Bureau of Mines and the Alabama Power Company at Gorgas, Alabama on underground coal gasification. If the process proves to be economical and successful, there is enough low-grade coal to supply all our hydrocarbon needs for the next 1500 years. The Russians have been rumored to have been successfully gasifying coal underground for a number of years, yielding gas for steam production and other processes. They have also been gasifying peat right at the peat bogs.

The experiments made in Alabama showed that the coal was burned clean, there was very little coke, and the ashes were on the bottom. In these tests, the experimental area at the mine was separated from adjoining coal by out-crops on three sides and an open cut on the fourth side. A U-shaped mine was developed in the coal bed, lying horizontally 30 feet under a hilltop, to form a pillar of solid coal 40 feet wide and 150 feet long inside the "U."

Five types of blasting were used, namely, oxygen-air, oxygen-air-steam, oxygen-steam, and steam blast and gas-air. The analyses of the gas samples which were given off show that the first three methods produced gases that could be used for generating power, while the oxygen-steam and steam blasts gave off gases suitable for synthesis purposes.

At the end of 50 gas-making runs, the mine was cooled initially with steam and then with water to permit examination of the underground residue. It was estimated that about 240 tons of coal had been burned completely and 160 tons had been coked during the combustion period.

The roof did not fall during the burning process as had been expected, but the rock became plastic under the intense heat, expanded and settled down on the mine floor directly in back of the reacting coal face. This roof action resulted in a uniform opening for air and gas passage along the coke-rock interface.

With the air blast, each pound of coal burned produced an average of 180 cubic feet of gas having an average of 47 Btu per foot. The steam runs gave 200 Btu per cubic foot, the air-oxygen 50 Btu, the air-oxygen-steam blast 110 Btu, and the oxygen-steam 135 Btu. These average values are much lower than were obtained under the most favorable conditions of the test.

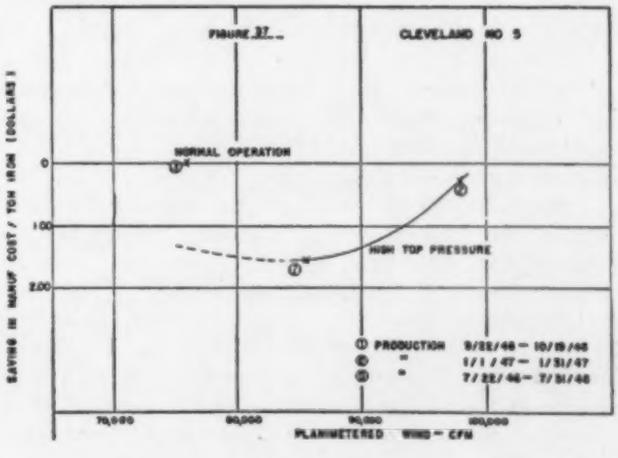
Much further work, however, remains to be done before the practicality of the scheme has been definitely determined.

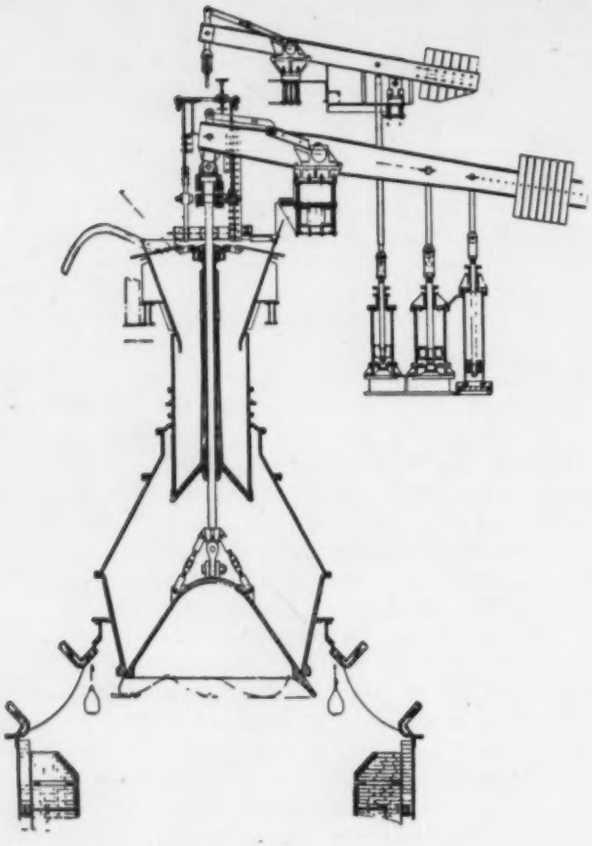
The American steel industry is not alone in its expansion program. For example, the present capacity of India is now estimated at 1,200,000 tons annually. This should be raised to 3,000,000 tons annually according to a report prepared by the Indian government. It is expected that it will take about 7 years to get such a plant in production and its location will be either in Bihar or western Bengal. These plans, of course, will probably be seriously affected by the present political upheaval now going on in that country.

Chile is being added to the list of countries who are establishing their own steel industry. A completely integrated plant, the first such in Chile, has just been authorized. This plant will produce 250,000 tons of finished steel products per year and is designed to use Chilean ore and Chilean coal. The plant will consist of five parts: coke ovens and auxiliaries for handling tar and light oils, equipment to purify the coke oven gas and gas transmission lines to serve industrial and domestic users, blast furnace; open hearth furnace, bessemer converter, and electric furnace; and finishing mills to produce flat-rolled and merchant products. The plant will be located on a bay affording deep water shipping facilities and it is estimated that it will cost about $50,000,000.

Another country doing extensive modernization work

Savings in cost of pig iron under certain conditions at Republic Steel Corporation's Cleveland No. 5 furnace.





Serrated bell used on blast furnace.

is Great Britain, where additional facilities are being constructed at almost every plant. Whether the industry will be nationalized or not, however, cannot be determined at the present time, and future developments will be dependent on this fact. In Germany, steel capacity will probably be greater than that initially estimated under the Morgenthau plan. In Australia, much work is being done on expansion of steelmaking and rolling mill facilities. As a result of the proposed foreign expansion, the past year has also seen a steady stream of visitors from other countries in the United States who have been studying plant installations here as an aid in making plans for modernization and expansion in their own countries.

BLAST FURNACES

The blast furnace is still one of the most efficient units in the steel plant and the development which has gone on through the year and which is being planned will increase its efficiency still more.

Present operational data seem to indicate that blast furnace size has probably reached a ceiling for the present time. Increased production can better be attained through better utilization of existing equipment and improvement in the raw materials. The methods to be used can be reduced to the following: coal washing, ore sizing, increasing top pressure, and oxygen enrichment of the blast.

One of these developments, which has been quite extensively reported during the past year, is the operation of blast furnaces under 10 psi top pressure. Two furnaces operated by Republic Steel Corporation have been operated under pressure since August 1946 with a 20 per cent increase in output and a 12 per cent decrease in coke consumption. This company is at present converting other furnaces to top pressure, and other companies are also planning such conversions.

Conversion changes required for pressure operation are relatively minor and cost from $70,000 to $150,000. Requirements are a one-piece hopper to give a tight seat for the big bell, equalizer valves to equalize the furnace and between bell pressures, wet washer level control to prevent blowing of seal, and a throttling valve to regulate top pressure. Blowers should be able to blow at pressures 6-8 psi above those normally used for the same wind volume. Under pressure, the furnaces required about 1490 lb coke per ton of iron, a saving of better than 200 lb per ton. Flue dust decreased from better than 200 lb per ton to 145 to 170 lb per ton in the Cleveland furnace. Smoother operation was also obtained in the furnace due to the lower gas velocity. The method also offers possibilities for the use of fine ores and ore concentrates which may change ore beneficiation requirements. Present plans contemplate runs under 20 to 25 psi top pressure and this work may point the way to still more efficient operation.

The use of an oxygen enriched blast has not yet been tried in this country although one 150-ton furnace is being set up for such operation, together with facilities for enriching the blast with oxygen. Some previous experimental work has been done in Germany and Russia. The oxygen enriched blast should decrease wind volume blown and the gas produced. There also will be less sensible heat carried into the furnace, because the heat produced is a function of the coke burned. This leads to one limitation of the process, that if there is less gas to preheat the stock, the top temperature will be lowered, and in contrast, heat requirements are decreased only by the amount necessary to preheat the coke. A point will be reached then, if the oxygen is increased, when the heat content of the gases in the lower parts of the furnace will not be enough to satisfy the top parts of the furnace. The German tests did show that production was increased 20 per cent with rich ores, and coke consumption about 100 lb per ton or 8 per cent. Oxygen in the blast was 25 per cent in this test. To break even, oxygen should cost less than $5.00 a ton. If the blast is enriched to 30 per cent, a furnace blowing 75,000 cfm air would require 12,000,000 cu ft oxygen per day.

That the top temperature decreases with the use of an increased percentage of the oxygen in the blast does not necessarily limit the maximum percentage of oxygen. Of great importance is the possibility that, if a blast furnace were designed for use with oxygen, the drop in the 212 F zone in the furnace would enable the construction of much shorter furnaces. A furnace operated with pure oxygen offers possibilities of a low furnace operated on lower grade fuel and lower grade burden, and this opens new vistas for the smelting process from the metallurgical and economic point of view.

One observation on the use of oxygen in the blast furnace is that German experimenters found the high

temperature zones around the tuyeres, which correspond to carbon dioxide production, to be reduced in volume by the introduction of enriched air. The highest temperature gases are thus nearer the sides of the furnace and it may be necessary to project the tuyeres further into the furnace with the use of oxygen.

The best possibility for the use of oxygen in the blast furnace would probably be its application to the ferromanganese furnace.

The blast furnace is assuming new importance because of a number of factors. Normally, blast furnace pig iron is combined with an equal amount of scrap, on the average, to make steel in the open hearth. Because of the excessive demand for steel and the shortage of scrap, the expansion of the blast furnace has become a key factor in expanding steel output. As an example, at the Ford River Rouge plant, a new blast furnace is being planned of 1400 tons daily capacity. The addition of this 1400 tons of hot metal a day may be more than enough to eliminate Ford as a steel scrap buyer, since its auto-making operations will probably produce more scrap than needed as well as possibly some for sale.

The purchase of the war-built blast furnace at Daingerfield, Texas, by the Lone Star Steel Company, provides a source of pig iron in an area where it has not been previously available except through expensive freight shipments. The furnace is also located only 3½ miles from a 4½ million dollar ore beneficiation plant located on east Texas ore deposits. The beneficiation plant uses some innovations not commonly used in the industry. The ore is a carbonate ore which is calcined before charging.

Another factor which will increase blast furnace capacity is the purchase by the Pittsburgh Steel Company of the government-owned incomplete blast furnace at Monessen, Pennsylvania, from the War Assets Administration. This furnace has a capacity of about 450,000 tons of pig iron per year and should be in operation by May 1948.

There are relatively few new changes in the design of blast furnaces. Carbon block linings are being used in many of the more recent furnace bottoms. The usual construction now is to install two courses of carbon blocks, each about 22 in. in depth, 30 in. in width, and up to 15 ft long. A 2 in. longitudinal space is left between these blocks for tamping with carbon paste. The expansion of the block and the paste is such that upon heating, a tight bottom is obtained at all times. Immediately adjacent to the iron notch, the blocks are set about 3 in. away from the cooling staves by an annular space which is packed with specially prepared coke breeze. The carbon construction costs about five times that of ordinary fire brick.

The trend in blast furnace linings, in general, is definitely towards hard-fired refractories, super-duty quality refractories, and carbon for the hearth. The super-duty brick is generally made of Missouri fire clays which fire to greater density than most other types.

It was reported during the year that the serrated bell design, which was installed on a furnace several years ago, has been rendering satisfactory service now for almost three years. The operation of this furnace compares well with others in the same plant operating on similar burdens, and the furnace has shown that it can take more wind per sq ft of hearth than other furnaces. Product yields and coke consumption compare well with other furnaces of the same size.

If the by-product coke has been made from ore which has been washed, beneficial effects are obtained on blast furnace operation. The better and more uniform coke which is used in the furnace results in the production of less slag because of the ash reduction. The amount of sulphur in the furnace is also reduced. Test runs made on washed and unwashed coal show an 8 per cent increase in production and an 8 per cent decrease in the coke consumed per ton of iron produced when using coke made from washed coal.

The growth of the pig iron industry in the west may be further accelerated by the investigations made by the Bureau of Mines on coal reserves in Colorado. Work during the past year in the Coal Creek District, Gunnison County, Colorado, has revealed three minable coal beds with reserves of 65,000,000 tons of coking coal and 35,000,000 tons of non-coking coal. Gas and a small amount of oil were also noted in the drilling operations.

One new development in coal operations will result from the placement of a $3,000,000 contract for a low-temperature coke plant by the Pittsburgh Consolidation Coal Company. The product is called Disco (from distilled coal). It is not directly competitive with the high-temperature methods of coke making. The proposed process will use, for example, low-grade coals of fine sizes, and is primarily aimed at meeting the demand for tar and tar derivatives. The process has the advantage of using lower cost raw materials, requires lower capital investments, and has lower operating costs.

Sintering in the processing of the ore is gradually increasing, and present capacity is now over 25,000,000 tons per year. Since about 80,000,000 tons are consumed annually, about 20 per cent of the blast furnace ore is now being sintered at a cost of $20,000,000 per year or an increase of about 1/6 over the cost of the ore. Since sintering is expensive and the product has some disadvantages in physical quality and strength, other methods are under development for agglomorizing, nodulizing and briquetting.

One of the largest additions to coking oven capacity last year went into service with the initiation of operations, at the Lorain works of the National Tube Company, of three new coke oven batteries of 59 ovens each, with an annual capacity of 800,000 tons. New features in the coke plant at Lorain include improvements in handling facilities such as installation of a rotary car dumper, increase in number of mixing bins, use of gravimetric mixers instead of volumetric mixers, use of conveyor belts with the car dumper, and facilities for splitting the coke breeze into pea coke.

The ovens are designed for firing with coke oven gas and later may be underfired with blast furnace gas by the addition of some auxiliary equipment. Electric precipitators are used to remove the tar from the coke oven gas. Ammonium sulphate production can be regulated to control the crystal size.

At the beginning of the year there were 1170 steelmaking furnaces in the United States, 924 open hearth, 29 bessemer converters, and 217 electric. Total capacity was 91,241,250 net tons, and throughout the year an effort has been made to keep all this capacity going continuously except that of the electric furnaces for whose product demand has slackened since the end of the war.

One of the chief problems in furnace operation this year has been the scrap shortage, and attempts to overcome this problem have been diversified. One method has been to use an increased amount of molten pig, and hot metal charged has been as high as 70 per cent of the total charge. This method has also been limited by the pig iron available. Iron ore charges have also been increased. Normally such charges are only sufficient to promote chemical reactions, but additional quantities have been charged to recover the iron content, and up to 13 per cent of the weight of the purchased scrap has been replaced by the iron derived from the iron ore. For this purpose, high-grade lump ore is necessary, and with each three pounds of ore, one pound of coke is required to promote the necessary chemical reactions. The time to make a heat is increased about 4 per cent because of the higher proportions of cold materials in the charge.

The most intensive development in steelmaking practice was the use of oxygen in open hearth operations. Such oxygen is used in two different ways. One use is to enrich the flame of the open hearth, thus creating a hotter flame, and reducing the melt-down period. The use of oxygen increases the flame temperature about 500 F above the normal 3300 F, and with a 10 — 25 per cent reduction in fuel. Melt-down time may be reduced also as much as 30 per cent.

The use of oxygen in the melt-down period can be particularly advantageous when scrap percentages are relatively high and charging is efficient. In general, the scrap charge should be at least 35 per cent before use of oxygen is indicated.

The second use of oxygen in the open hearth is to bubble the gas into the molten bath and increase the rate at which carbon is removed from the liquid metal. The temperature of the bath is also increased by this operation thus further speeding carbon removal. Savings in time due to this run from 17 — 30 per cent.

Most of the work which has been done has been based on the use of 99.5 per cent pure oxygen. Work with oxygen purities that are less than this figure, indicate the same amount of oxygen, although of lower purity, would be as effective in carbon reduction. Compressed air can also be used effectively in accelerating carbon reduction. However, the low-purity injections, because of the greater volume of air required, cause more splashing and may give more smoke, and the increased splashing may have some adverse effects on the refractories.

Variations in the actual procedure of introducing oxygen into the steelmaking plant are many and which ones will be eventually used cannot as yet be determined. The following procedures have been tried in using oxygen to shorten the melt-down period:

1. Introduction of oxygen in the burner (usually oil or tar-fired design).
2. Introduction of oxygen through auxiliary burners.
3. Oxygen through the checkers.
4. Introduction of oxygen through jet directly on preheated scrap.

Oxygen is also used for decarburization or carbon reduction in the following ways:

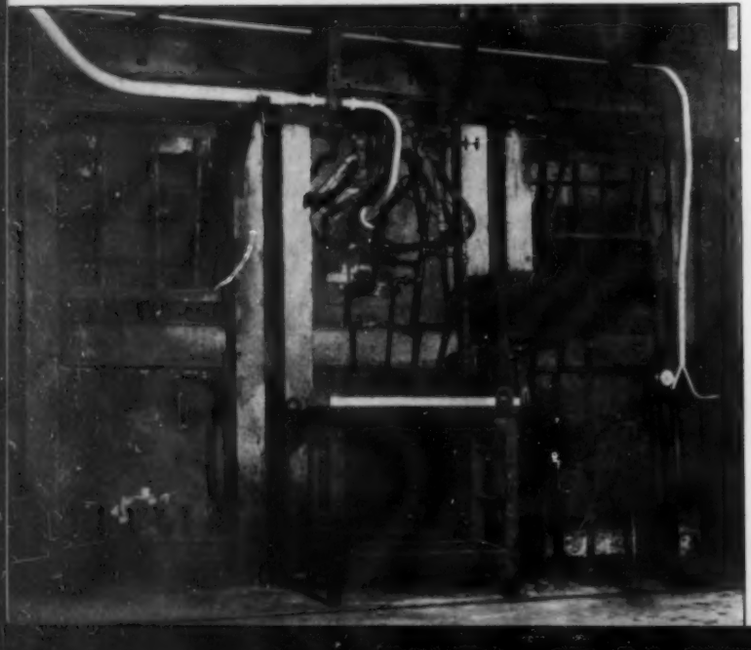
1. Introduction into the bath through a lance.
2. Introduction into the bath through a water-cooled jet. End of jet is held above slag and supersonic velocity of oxygen forces it into bath.

Oxygen in main burners — The chief reason for using oxygen in the main burners is to improve heating flame characteristics to obtain higher flame temperatures. Burners are usually oil or tar fired and of two types. One contains an annular passage which supplies relatively low velocity oxygen in a sheet around the fuel, and the other contains a single passage which supplies high velocity oxygen below the fuel. The design which shows the greatest promise uses a supersonic velocity jet below and parallel to the fuel jet. The fuel rate is increased and the flame is shortened to such a degree that it does not go into the downtakes. Since the oxygen is under the fuel jet, an area of higher flame temperature and greater radiation is obtained on the bottom side of the flame, while the top side of the flame which radiates to the roof is about the same as normal firing conditions. Use of oxygen through end burners shows increased radiation of about 10 per cent over most of the flame dropping to 5 per cent at the opposite end of the furnace from the burner. The use of oxygen in end burners results in a 10 to 25 per cent reduction in charge to tap time at an oxygen consumption of 400 — 750 cu ft of oxygen per ton of steel per heat. Scrap must be charged at a rate equal to the melting rate if full advantage of the oxygen is to be made.

Rapid melting of scrap causes heats to melt higher in carbon and may require some adjustment of charging ratios. Reduction of absorption of sulphur from the fuel may be expected.

Oxygen through auxiliary burners — Since the highest

Oxygen piping on end of open hearth furnace is shown in white. Branch line on right is used for lancing.



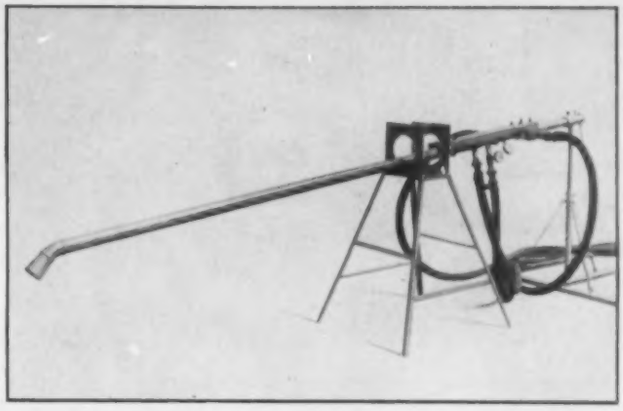
rate of heat transfer occurs when high intensity, high temperature flames impinge directly on the material to be heated, attempts have been made to improve the rate of charge melting by using auxiliary burners, to furnish stoichiometric correct oxy-fuel ratio flames, and by directing these flames at the charge. Much testing has been done on such auxiliary burners, both in an experimental test kiln, and in a four-ton experimental open hearth furnace at one of the steel plants. Burners were inserted through wicket doors and moved so that the flame impinges on unmelted portions of the charge at distances of 10 to 30 inches. Similar tests have also been run in a 175-ton open hearth.

The results of six heats on the 175-ton furnace gave an average saving of 1.6 hours in charge to tap time with an oxygen consumption of 200 cu ft per ton. However, the sharp, intense flames produced with stoichiometric quantities of fuel and oxygen were too short to be effective. On the other hand low velocity flames from auxiliary burners were deflected by the main burner flames, and high velocity flames in the auxiliary burner deflected the main burner flame and caused erosion. Thus far, this technique can be considered only as experimental, though it does offer possibilities.

Oxygen through checkers—Introducing oxygen through the checkers at a point just ahead of the checkers has also been tried with enough oxygen to raise oxygen content about 2 per cent. It is claimed that this method will increase the scrap melt-down rate, rate of temperature rise before tapping, give a more rapid rise of heats where the bath is not agitated enough for satisfactory heat transfer from the normal burner flame, and reduce foam and frothing in the slag.

Oxygen through jet — Oxygen directed at preheated scrap is another variation of this process. In this method, high velocity oxygen is directed through a jet to the preheated scrap. Preheating is done with the regular end burner. Higher oxygen utilization efficiencies have been achieved in oxygen-jet melting studies than were obtained with similar amounts of oxygen in end burners. With a charge of 60 per cent cold scrap, a 25 per cent reduction in charge-to-tap time resulted from injection of 40 cu ft of O_2 per ton of preheated scrap in a 180-ton furnace through a jet at a rate of 30,000 cfh. This result gives a merit factor more than 3 times higher than that for the best value computed when using burners. Much of the iron oxide produced by the burning of the iron is probably converted back to iron during the refining period.

Oxygen in bath through lance — Probably more experimental work has been done on the introduction of oxygen into the bath through a lance than on any other method. In normal ore practice, carbon reduction rates average about ½ point per minute, whereas the introduction of 100 to 300 cu ft of oxygen per ton of metal will increase the carbon reduction from two to five times. In the early work which was done, a 1 in. pipe lance was used with the end in the metal bath. Lances under this treatment last only a few minutes. Later on, it was found that the same effect could be obtained by inserting the lance only into the slag, and the life of the lance would then be increased to over an hour. However, the use of oxygen decarbonization in this method is still awkward, and oxygen supply lines and so forth offer interruption to other work in the open hearth.

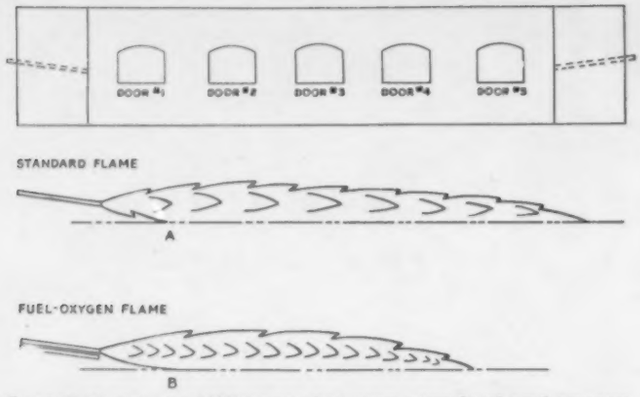


This jet device was built for operation with an oxygen flow rate of 3000 to 70,000 cfhr. From 500 to 2000 gphr water are required for cooling.

Introduction of oxygen into bath through the jet — A water-cooled jet device was developed which has been found to be of more convenience in operation than the use of the lance. High velocities of oxygen in the order of 1300 to 1500 fps are used, and with this velocity the end of the jet can be kept 3 to 6 inches above the slag and the force of the oxygen forces it into the metal bath. There is also a good resultant agitation due to this pressure. Operational results with the use of the jet and lance indicate that production in tons per hour may be increased from 10 — 35 per cent. Nothing conclusive can be determined as yet, as to whether operation with the jet is better than the lance or vice versa, except that when oxygen injection through the lance was about twice that through the jet, the rate of carbon reduction obtained with the lance was only about 30 per cent higher than the jet. Some operators, however, state that the jet is not as efficient as the lance in low finishing carbons in the order of 2 — 3 points. For a constant rate of oxygen injection, the rate of carbon removal decreases as the carbon content is reduced, which is what would be expected from the usual laws of chemical concentration. Some shops have used an increasing rate of oxygen injection as the carbon content was lowered, but such practice increases splashing with deleterious effect on the refractories.

A factor in the use of ore in the bath is the heat pick-up due to the oxygen injection. The increase in the temperature may be controlled by the addition of ores to the bath during the agitation period.

A good bit of work has been reported on what was done at one steel plant on the introduction of pure oxygen in the bath for rapid carbon removal. About 10 per cent of this company's production is for steel of 0.07 per cent carbon and lower, about 85 per cent of the production is from 0.07 to 0.10 per cent carbon. This plant has found that on the basis of oxygen costing $80 per ton, it has been practicable to use oxygen because of the decreased charging and finishing times. The practice here has been to introduce the oxygen at about 100 psi pressure into the bath through a pipe through the wicket hole. This plant found that the most rapid carbon drop with the lowest oxygen consumption took place when the end of the pipe was kept 6 to 10 inches below the surface of the steel. Lance consumption was



Sketch illustrates difference between standard and oxygen enriched flame. Standard flame has length about 53 ft; height 3 ft; fuel flow is 350 gphr; steam flow is about 1100 lb per hr. Enriched flame has length about 38 ft; height is 3 ft; fuel flow is 500 gphr; steam about 1100 lb per hr; and O_2 is 25,000 cu ft per hr.

about 2½ fpm and the length of pipe lasted about 6 minutes. For equivalent type heats, it was found that with the use of oxygen, a heat which normally took an average of 2 hours and 35 minutes and 12,000 lb of ore, to get from 0.10 per cent carbon to tap, could be worked in 50 minutes by blowing the bath with from 7000 to 20,000 cu ft of oxygen. The fuel saving (computed from average fuel rates) was sufficient to pay for the oxygen. In addition, there is a difference of 50 minutes in the total heat time.

It has been found that the supply line to each furnace from the main oxygen line should be about 2½ inches in diameter and requires a shut-off valve, an indicating oxygen flowmeter, and a pressure gage. These items should be located so that the operator at the oxygen take-off valve can easily observe the instruments. The take-off taps are 1½ in. in diameter, the pipes are equipped with 1½ in. flow valves, and it is advisable to have more than one take-off.

In general, the use of 100 to 300 cu ft of oxygen per ton of metal accelerates the decarburizing rate by factors of 3 to 5. The injection of 1 cu ft of oxygen per ton raises bath temperatures 1.1 F assuming that all heat enters the steel. The reduction of 1 point of carbon with O_2 then corresponds to 2.9 F rise in bath temperature. The overall reaction with ore reduces bath temperatures 3.9 F per point of carbon removal. The benefits resulting from injecting oxygen into the bath are thus shortening of period to reduce carbon, increase in temperature, fuel saving, better furnace control, reduction in limestone, and improvement in sulphur elimination.

The principal problems which must be overcome before most advantageous use of oxygen can be obtained are better refractories, a cheaper supply of oxygen, and an economic solution to the problem of dust and fumes. Although[1] it has been shown that heat time can be reduced up to 40 per cent and fuel consumption decreased 30 per cent at one plant by the use of oxygen, monthly production rates at this plant were not impressive because of the time furnaces were out of service for brick work, which was largely roof failure from splash and iron oxide penetration.

Next to refractories, the emission of dust while using the oxygen lances is the most serious problem. After experimenting with the pilot plant in one installation, the furnaces were equipped with 85 per cent efficient waste gas scrubbers located after the waste heat boilers to reduce the dust escaping into the atmosphere. However, better dust collection will be required. The experiments with the pilot plant showed that 95 — 98 per cent removal could be obtained with a water-flooded venturi tube located before and in conjunction with the existing scrubbers. Research done on the red to chocolate fume emitted while lancing with oxygen showed it to be highly magnetic and roughly 88 per cent ferric oxide with a particle size of 0.115 — 0.183 microns. The dust content of the waste gas entering the washer during the lancing ranges from 1 — 6 grains per cu ft corrected to 60 F.

Oxygen offers possibilities also in the bessemer converter. A 45 per cent air blast has been used in Germany with favorable results. Kapitza with higher percentages of oxygen has reduced the blow-time from 15 minutes to one minute.

Oxygen offers possibilities for shortening the flame with both oil and producer gas. This can then be directed at the item to be heated without raising the temperature of the furnace lining as much as with the normal flame.

Oxygen supply for steelmaking operations at present are obtained in the common 220 cu ft tanks, in tank trucks when demands run from 50,000-750,000 cu ft per month, and in railway tank cars with capacities of 750,000 — 1,000,000 cu ft. What the final form of supply will be depends on the future market that develops, and the purity which is found economical.

The oxygen generated for the steel industry is divided into two types. One is a high-purity (99.5 per cent) type which requires special equipment to remove practically all of the argon and the nitrogen from the oxygen. The other is the lower-purity type (80 to 95 per cent) which requires simpler equipment and which because of the many other factors such as being generated in large amounts requires less power and labor. The lower-purity type of oxygen eliminates the costly equipment unless the oxygen is needed at pressures much above atmospheric.

Construction of plants for producing oxygen in the steel plant may be the answer to the problem of supply. It has been estimated that a plant producing 100 tons a day (2,400,000 cu ft) of 90 — 96 per cent oxygen would cost $940,000, require but two men to run, and would supply oxygen at 18 cents per 1000 cu ft. Power costs in manufacture of oxygen are 11 — 15 kwhr per thousand cu ft.

One $4,000,000 oxygen plant is under construction by one of the steel plants, and will be used in increasing iron and steel output. Capacity will be 400 tons of oxygen per day.

One of the oxygen manufacturer's has just built a large pilot plant which can produce 400,000 cu ft of 99.5 per cent pure oxygen per hour. For some time, about 200 tons per day of this production has been made of various purities and then blown off to develop techniques and costs for oxygen of varying purity, pressures and demand factors.

If the operations on oxygen plants which now are being installed in this country check with European practice, oxygen-producing units of the larger sizes

SUMMARY OF OPEN HEARTH HEATS USING OXYGEN THROUGH END BURNERS

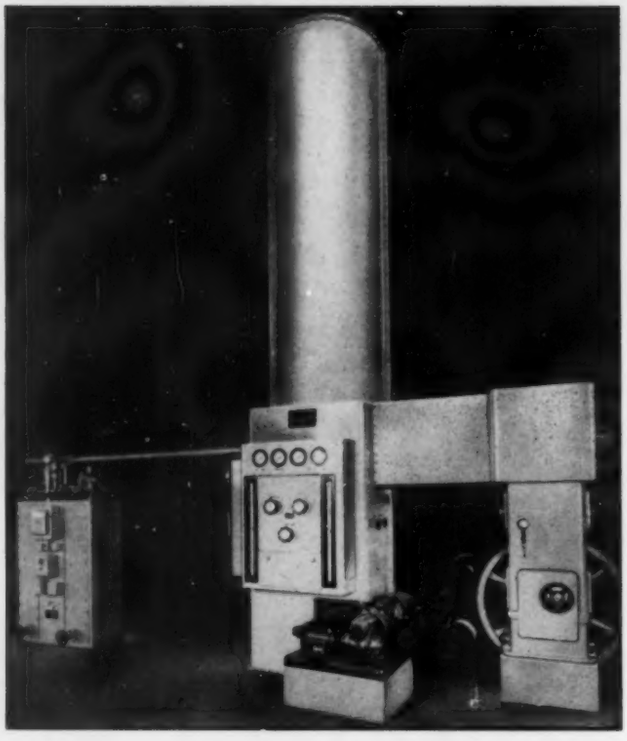
Mill	A	A_1	A_2	A_3	A_4	A_5	B	C	C_1	C_2	C_3	C_4	D	E	F	G	G_1	H	H_1
Size of heats tapped, tons ingots	64	219	225	227	228	224	175	201	198	196	201	197	100	183	124.4	126	130	236	232
No. of O_2 heats avgd. for data below: Total No. of Heats - 728	20	20	13	28	64	47	53	48	58	30	102	51	23	20	18	8	4	21	120
Average charge: Percent scrap	60	60	60	60	60	60	61	22	35	22	32	22	40	53	51	32	49	60	58
Percent molten metal	--	40	40	40	40	40	39	78	65	78	68	78	52	47	44	53		37	37
Percent cold pig	40	--	--	--	--	--	--	--	--	--	--	--	1	--	--	4	47	3	5
Percent ore	--	--	--	--	--	--	--	--	--	--	--	--	7	--	5	13	4	--	--
Fuel	Tar	Tar	Tar	Tar	Tar	Tar	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil	Oil
Practice	C.Metal	H.Metal	H.Metal	H.Metal	H.Metal	H.Metal	H.Metal	H.Metal	H.Metal	H.Metal	H.Metal	H.Metal	H.Metal	H.Metal	H.Metal	H.Metal	C.Metal	H.Metal	H.Metal
Mil.-B.t.u.'s/ton, tap-to-tap, with O_2	4.5	2.87	3.77	4.33	3.69	4.17	3.94	3.99	--	3.02	4.75*	2.85*	--	--	3.66	3.45	4.31	4.16	4.59
Mil.-B.t.u.'s/ton, tap-to-tap, without O_2	4.5	3.60	3.60	4.25	4.34	4.34	3.95	3.85	3.85	3.85	--	--	--	--	--	--	--	--	--
Fuel-gph. during meltdown, with O_2	282	458	462	506	493	530	556	--	--	--	--	--	381	490	375	393	383	681	651
Fuel-gph. during meltdown, without O_2	160	330	330	360	--	--	415	--	--	--	--	--	320	430	333	--	--	--	--
Average O_2 flow, cfh.	31,400	51,000	55,700	26,600	36,600	25,200	47,100	93,840	**	**	**	**	25,700	23,900	16,400	14,250	16,700	48,500	21,050
Duration of O_2 flow, hours	3.3	3.5	4.1	4.1	5.0	3.6	3.2	2.0	--	--	--	--	2.7	3.4	2.6	3.6	5.5	4.0	4.4
Total O_2 used, cu.ft./heat	103,600	178,100	228,900	107,600	182,200	90,700	150,800	87,700	177,800	217,400	194,500	242,000	69,300	81,200	42,000	51,400	91,800	194,300	92,300
Total O_2 used, cu.ft./gal.fuel (during melt)	111	111	120	53	74	48	83	--	--	--	--	--	67	49	43.7	36	44	71.2	32.4
Total O_2 used, cu.ft./ton of ingots	1610	811	1020	474	799	405	871	436	898	1110	969	1228	693	462	337	443	705	822	398
Oxygen other than burner use, cfh.	--	--	--	--	--	--	--	--	47,900	132,400	71,500	146,500	--	--	--	--	--	--	--
Chg.-to-tap time in hours, with O_2	8.2	9.6	11.9	14.90	11.37	12.95	10.4	11.0	11.36	8.95	12.00	9.18	7.2	9.1	8.7	7.4	10.1	13.7	14.7
Chg.-to-tap time in hours, without O_2	11.8	13.2	13.2	15.22	15.55	15.55	13.4	12.0	12.00	12.00	12.00	12.00	8.7	11.0	11.5	9.9	13.0	15.2	15.4
Percent decrease, with O_2	31	27	10	8.8	26.9	16.7	22.0	8.0	5.32	25.4	0	23.5	17.3	17.3	24.2	25.3	22.3	9.9	4.5
Time to charge scrap	--	2.5	3.0	4.4	3.25	4.2	--	--	--	--	--	--	--	--	--	--	--	4.6	4.8
Tap-to-tap time in hours, with O_2	9.1	11.2	13.9	15.57	13.75	14.62	12.0	--	--	--	--	--	--	10.6	9.2	--	--	15.3	16.1
Tap-to-tap time in hours, without O_2	13.6	14.5	14.5	17.30	17.12	17.12	--	--	--	--	--	--	--	--	12.0	--	--	16.7	16.8
Percent yield, average with O_2	--	--	--	--	--	--	85.8	90.6	--	--	--	--	87.5	87.5	--	83.5	90.0	--	--
Percent yield, average without O_2	--	--	--	--	--	--	85.4	91.0	--	--	--	--	--	--	--	--	--	--	--
Tons/hr. charge-to-tap, avg. with O_2	7.79	22.9	18.9	16.35	20.03	17.30	16.6	18.2	17.4	21.85	16.75	21.45	13.9	20.1	14.2	17.0	12.9	17.3	15.8
Tons/hr. charge-to-tap, avg. without O_2	5.42	16.6	16.6	14.73	14.16	14.16	12.9	16.7	16.7	16.7	--	--	11.5	16.7	10.8	12.7	10.0	15.6	15.1
Percent increase in production	43.7	38.0	15.8	11.0	41.5	22.2	28.7	8.9	4.2	30.8	--	--	20.8	20.3	31.7	33.8	29.0	10.9	4.6
Merit Factor	1.9	3.3	1.0	1.9	3.4	4.1	2.5	1.8	0.6	2.3	0	1.9	2.5	3.8	7.2	5.7	3.2	1.2	1.1

* Based on charge-to-tap time

** No average rate or time of use available

Bk. No. Lab 1978

Revised: April 9, 1947



This oxygen generator can make 2100 cu ft of high purity oxygen per hour.

should provide oxygen of 80 per cent purity or higher at a cost of less than $10 per ton.

The past year has brought forth some new improvements in electrical furnace design and in the development of a furnace to be used with duplexing work. The result is a so-called fore-hearth type of electric furnace which is nothing more than a standard furnace built to operate with a deeper bath and with the main power transformer designed for special voltages to permit rapid duplexing of molten metal.

One development in duplexing steel has been the adoption of a setup consisting of a basic cupola and an acid electric furnace for the production of iron in the 1.20 — 1.45 C range. Such a setup would normally be used for production of iron with 2.0 — 3.5 per cent carbon.

In Europe the electric furnace has been adapted for smelting ores. The design is called the electric low shaft furnace and is made in two designs, the Tysland-Hale furnace and the Siemens electro-smelting furnace. With identical burdens, the electric and the blast furnace from an energy consumption standpoint are equivalent if the price of 1 lb of coal is about 3.6 times that of 1 kwhr of electricity. On an overall basis, economy is equivalent if the cost of 1 lb of coal is about 2.7 times that of 1 kwhr. The electric smelting furnace will allow the use of an inferior coal, and require about 10 per cent less coal than blast furnace, the latter item resulting in proportionately less sulphur in the electric-furnace pig iron. The gas from the furnace is about one-sixth carbon dioxide and five-sixths carbon monoxide.

Steelmaking practice developments during the year were concentrated on effecting maximum production. The average open hearth furnace is now generally about a 200-ton furnace and should tap at least 400 tons per day. This furnace uses oil as a standard fuel and this is supplemented by tar, pitch, and by-product gases. Basic front walls and ends are found in many shops.

One 122-ton all-basic furnace has been built and is in production. This furnace has all-basic refractories with the exception of the walls and roofs of the checker chambers, the checker brick, floors and bulkheads of the slag pockets, and the roofs of the fantails. The furnace was built as an experiment to obtain information on the all-basic lining and also in the use of oxygen.

Open hearth bottoms are now, in general, being made of brick construction lightly surfaced, or of brick construction with a heavy rammed surface, or with a sintered magnesite surface. The element in the refractory which resists slag attack is magnesia, and a refractory which gives the greatest amount of magnesia is the one that is most likely to render best service.

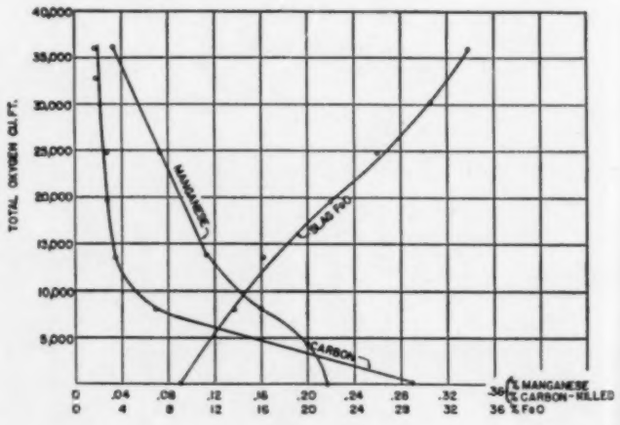
While basic brick has higher fusion points than silica brick, they have two inherent weaknesses, namely that the basic brick softens under load at high temperature due to the presence of small amounts of low temperature bonds, and this is the usual reason why they have to be suspended. In addition, basic brick tends to spall more readily at high temperature than silica brick. Another property of the brick is its action which absorbs into the hot face of iron oxide, lime and silica which may be available on the surface, and when the roof is chilled, this impregnated face has a tendency to spall.

Refractory concrete was used in building open-hearth flues in some installations during the year. The use of concrete saved rebuilding time and allowed easier construction of continuous changing passageway sections. Cost was reduced about fifty per cent. The first such flue was built in 1943, and on this flue, no crackings other than superficial checking has been noted.

A new air-emplaced refractory using a Cuban chrome ore as a base, as well as a new emplacement gun with a capacity of over 100 lb per minute will facilitate speedy repairs in furnace refractory sections which are otherwise hard to reach.

Some recent work has been done on experimentation on pouring rates through nozzles ranging from 2 — 4 in.

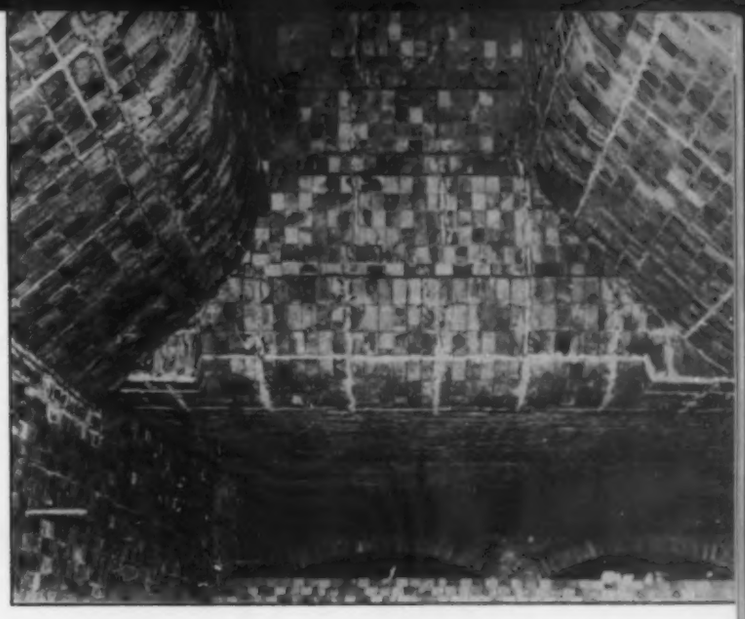
Change in slag and metal analyses with oxygen blown through bath. Oxygen blown at rate of 57.3 lb per min at 90 psi.



in diameter on rimmed, mechanically capped, and semi-killed low carbon steels to investigate the effect on slab surface quality. A decided improvement in quality was found with the increased pouring rate, and in the case of rimmed steel surfaces, slabs from heats poured through 4-in. nozzles required a removal of only 2.4 per cent compared with 15 per cent for heats poured through 2-in. nozzles. Molds were 30 × 48 in. and 31 × 56 in.

Graphite molds have been used for the casting of small ingots. The use of these molds was found to be economical, as mold life was increased 14 times while the initial cost was 4 times the iron mold. Stickers were eliminated, surface condition was better, grain structure was improved, and there was no carbon pickup.

Shortages in steel production this winter due to lack of fuel should be minimized by the preparatory work undertaken by some of the steel companies during the past year. One company has shipped in a number of tanks of liquid propane which will be fed to a gasifying plant, when required, as an emergency fuel. Furnaces have also been converted to permit them to use fuel oil as well as natural gas. Similar work has been done at some of the other plants.



Uptake walls and upper part of slag pocket of experimental all-basic open hearth furnace.

ROLLING

The largest single item of steel plant expansion or modernization during the past year was in the field of installation of new rolling mills, particularly strip mills, or the speeding up and modernization of existing mills. Most of the new coal reduction strip mills are either 3-stand, 4-stand, or 5-stand 42 or 54 in. mills, although two 93 in. 3-stand tandem mills are being installed. About 22 such mills have been recently completed or are under construction. Approximately 12 reversing cold strip mills are on the present program as well as 6 new hot strip mills. Much work is also being done on skin or temper pass mills and 16 of these, ranging from 26 — 84 in. are on the program. The program for rolling mill items other than strip consists of about 12 continuous bar and rod mills, 6 reversing blooming, slabbing and billet mills, and 8 tube mills.

One new historical landmark was reached during the year when the first "mile-a-minute" tandem cold mill was put into operation on May 13, 1947. This mill, a 42-in., 5-stand, 4-high tandem cold mill is capable of rolling 0.008 in. and less from hot rolled and pickled strip 0.093 in. thick at speeds up to 5000 fpm. The work rolls are 21 × 42 in. and the backup rolls are 53 × 41 in. Twin motor drives are a feature of this installation and this mill is the first cold reduction mill to utilize such drives which are on stands No. 4 and No. 5. The first three stands have direct drive. Coils can be rolled 26,000 feet long, weighing up to 30,000 pounds.

The year brought out one new development in cold strip mills. This mill (a 20 in. mill) unique in its application of small diameter driven work rolls, is known as the Y-mill from the shape of the roll layout. The mill can transmit 900 hp through the necks of the working group of rolls with peaks as high as 1100 hp. Efficiency is increased due to small work rolls and to the reduction in forward slip, sidewise spread, and compressive resistance of metal. Greater overall reduction can be obtained without intermediate annealing as well as extreme accuracy of gage. The mill consists of 7 rolls with a 6⅛ in. diameter bottom driven work roll backed up by 19⅜ in. diameter bottom backup roll. Above the lower work roll is a 3¼ in. diameter work roll which is backed up by two 6⅛ in. diameter driven rolls at 90 degrees with each other, which rolls in turn are backed up by 17¾ in. diameter backup rolls. The mill is designed for a total separating force of 720,000 lb. This 20 in. reversing mill has been built to roll strip of 17 in. width at delivery speeds of 600 to 1200 fpm. A 600 hp mill motor drives the working rolls. The mill has accurate gage control, can roll thin strip as well as heavier gages, gives greater overall reduction, reduces forward slip and spread, has lower tension and roll pressures, and at the same time gives production comparable with conventional mills. The mill can also be used for high and low carbon, and stainless steel for cold reduction and temper rolling.

The Sendzimir precision cold strip mill was selected for additional installations during the year. One such small unit was installed by one of the smaller steel companies for cold rolling of stainless steel strip. This mill is being used for rolling stainless steel to extra thin gages and widths up to 36 in. and holds both finish and gage consistently throughout the coil. This mill is capable of producing about 1500 tons of extra light gage stainless steel per month in thicknesses of 0.004 to 0.078 in. This 36 in. mill is the widest such mill ever built.

It is claimed that one new mill, a 5-stand, 4-high cold reduction mill recently built, can reduce cold strip 36 in. wide and 0.10 to 0.125 in. thick, in one pass. The strip leaves the mill at speeds up to 4000 fpm. Capacity of the unit is about 60 tons of tinplate per hour and it can handle strip up to 52 in. in all commercial gages. Work rolls are 56 in. long and 21 in. in diameter. The mill has tensiometers between roll stand to regulate the mill motors' speeds, and flying micrometers to give the

General view of entry end of mile-a-minute tandem cold mill.

operator a true picture of the thickness of the strip over the entire length.

A new 66-in. reversing hot strip mill being built has the unusual feature for this type of mill of rolling the strip flat by passing it back and forth through the mill until the thickness is reduced to about ¾ in. The strip then is directed into a coiler built into a furnace above the mill table. On the next pass, the strip comes out of the coiler, runs through the mill in the other direction, and goes into a similar coiler on the other side. These coilers enable the strip to retain the heat so that it may be rolled in the reversing mill without reheating, down to thicknesses such as usually are produced on tandem mills.

A recent chain type leveler design incorporates a continuous roll backup support extending the full length of the roll, with leveling rolls which are laced into double width roller chains on hardened steel pins. The rolls are combined into two sets of endless chains operating on double chain sprockets. The leveler can handle a greater range of gage than the conventional leveler with the same diameter work roll and a greater number of leveler rolls are engaged in working the sheet. The position of the rolls can also be adjusted so that the unit will operate as a cold reduction mill instead of as a leveler.

One mill product which is in very short supply is that of pipe. A number of new pipe mills are being installed throughout the country. The largest such installation are the additional facilities being built by the National Tube Company at Lorain, Ohio. Most pipe mill expansions have been delayed somewhat by shortages in electrical equipment and other supplies. Production of pipe and tube in 1947 was about 5,900,000 tons, which was greater than in all of the past years except the war years. Pipe is in particular demand for the construction of pipe lines.

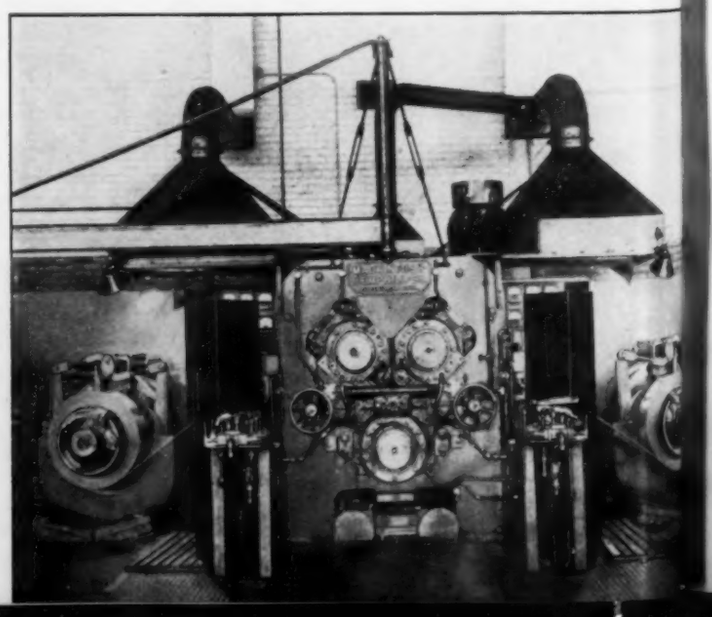
Among the innovations in the National Tube expansion is a new seamless mill to manufacture 2 — 4 in. pipe. Modifications have been made in the piercing pass to increase the delivery speed of the piercing mill 100 per cent. In addition, the new mill is set up as a continuous tube rolling mill consisting of 9 tandem individually powered stands of 2-high grooved rolls and thus the new mill is very similar to the modern strip mill. The difference is, of course, that the mill uses an internal mandrel against which the work piece is rolled and this mandrel extends entirely through the pierced billet and passes through the mill with the work piece. The mill delivers pipe in 65 ft lengths at rates up to 900 fpm, and the overall wall reduction is about twice that made in the conventional 2-high mill.

Rotary hearth billet heating furnaces have been developed for heating of the billets prior to piercing. After the material has gone through the 9-stand mill, the roll tubes are reheated before processing in the tension sizing mill. This mill consists of sixteen 2-high roll stands in which the tube is reduced by tension without the use of a supporting mandrel, and the wall thickness is diminished while the diameter is reduced. Reduction can be obtained up to 20 per cent greater by this process than in the conventional mill. The maximum delivery speed of the pipe which comes out of this unit is about 2200 fpm. The monthly capacity of this unit is about 18,000 tons.

During the past year the extrusion method, used in the nonferrous industry for many years, has been improved so that it has been made practicable for extruding tubes, billets of stainless steels, special steels and nickel alloys. These materials are extruded at temperatures up to 2400 F and depend on fast-working presses and high-quality wear- and heat-resisting tools. One of the advantages of the method is that solid billets can be converted to finished products in only a few seconds during which time no change in temperature takes place. This is of particular advantage in the case of those alloys which can only be hot-worked within a very narrow temperature range. A heavy grease is used to prevent the metal from welding with the tools. In this country, a 4000-ton double-acting press is in service which extrudes tubes of 3 — 8 in. outside diameter from billets 7 — 12 in. diameter.

Another extruding operation is a variation of the technique which the Germans developed for the manufacture of steel cartridge cases. This process is a cold extrusion process using presses ranging from 50 to 2500

Front view of Y-mill stand and coiler.



tons capacity. One of the secrets of the process is apparently a phosphate coating which is put on the surface of the blank and all other parts after annealing and pickling. This coating seems to lubricate the steel so that it will flow in the die under pressure. In addition, the first choice for the lubricant is rape seed oil.

FINISHING

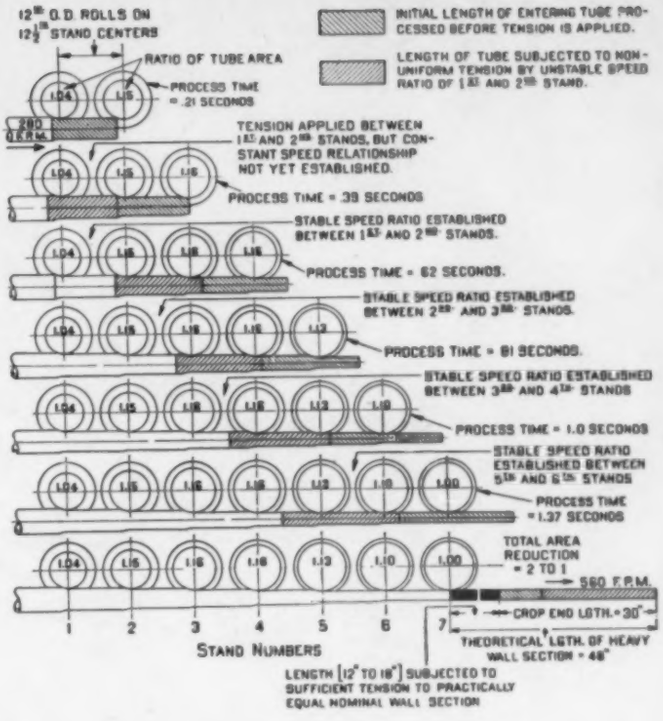
An automatic machine for conditioning blooms, billets, slabs and sheet bar has been developed. This machine eliminates the variations in grinding due to the human element resulting in a better production. The machine features wet grinding, which smothers the injurious grinding dust and gives wheel economy.

A similar type wet grinding finishing machine recently developed will grind both sides of cut or coiled sheet and strip at the same time. The unit has an oscillatory movement to break up directional grinding marks. The machine can be used for polishing and buffing as well as for heavy grinding to remove surface defects. Two sizes have been built for 24 and 42 in. wide sheet, and others are being designed for widths up to 60 in. The grinding is done by abrasive bands wound on pneumatic rubber drums. Normal operations usually require three batteries of grinders in tandem.

A new method has been developed of plating nickel and cobalt on metal surfaces without the use of current. The process, developed at the National Bureau of Standards, is called "electroless plating." The process is accomplished by chemically reducing nickel or cobalt salts with hypophosphite in hot solution. The reaction is catalytic and under certain conditions of pH and concentration, plating occurs only when certain metals as steel or nickel are introduced in the bath. Reduction occurs only on the surface of the immersed metal, forming a coating of 93-97 per cent purity.

In making tin plate, the trend during the past year has been strongly upward in the production of electrolytic tin plate. July 1947, for the first time, saw electrolytic tin plate exceed in tonnage the production of the hot dip process. By 1950, hot dip production will probably drop to about 34 per cent of the total coated products made. Tin was short during the year, and production in 1947 was about 50 per cent the prewar rate. Output in 1947 of tin plate on the other hand hit a new high of approximately 3,500,000 net tons. The electrolytic capacity of the industry had been reduced from 2,231,000 tons in 1946 to about 2,000,000 tons for 23 electrolytic lines due to taking some out of operation. The chief problem in increasing production has been the shortage of cold reduced sheet and strip rather than tin. Although, the hot dipped plate may not be as big a factor as the electrolytic plate in the future, it will still probably be the only effective answer for some uses such as canning acidic fruits and berries.

It is now possible to obtain a fully developed process for separating and recovering in metallic form both the zinc and iron from galvanizing dross produced in the galvanizing mills. The process consists in raising the temperature until the more volatile materials are vaporized, and the remaining materials are drawn off as a liquid. The distillation temperature is in general around 3000 F and thus requires special equipment for carrying

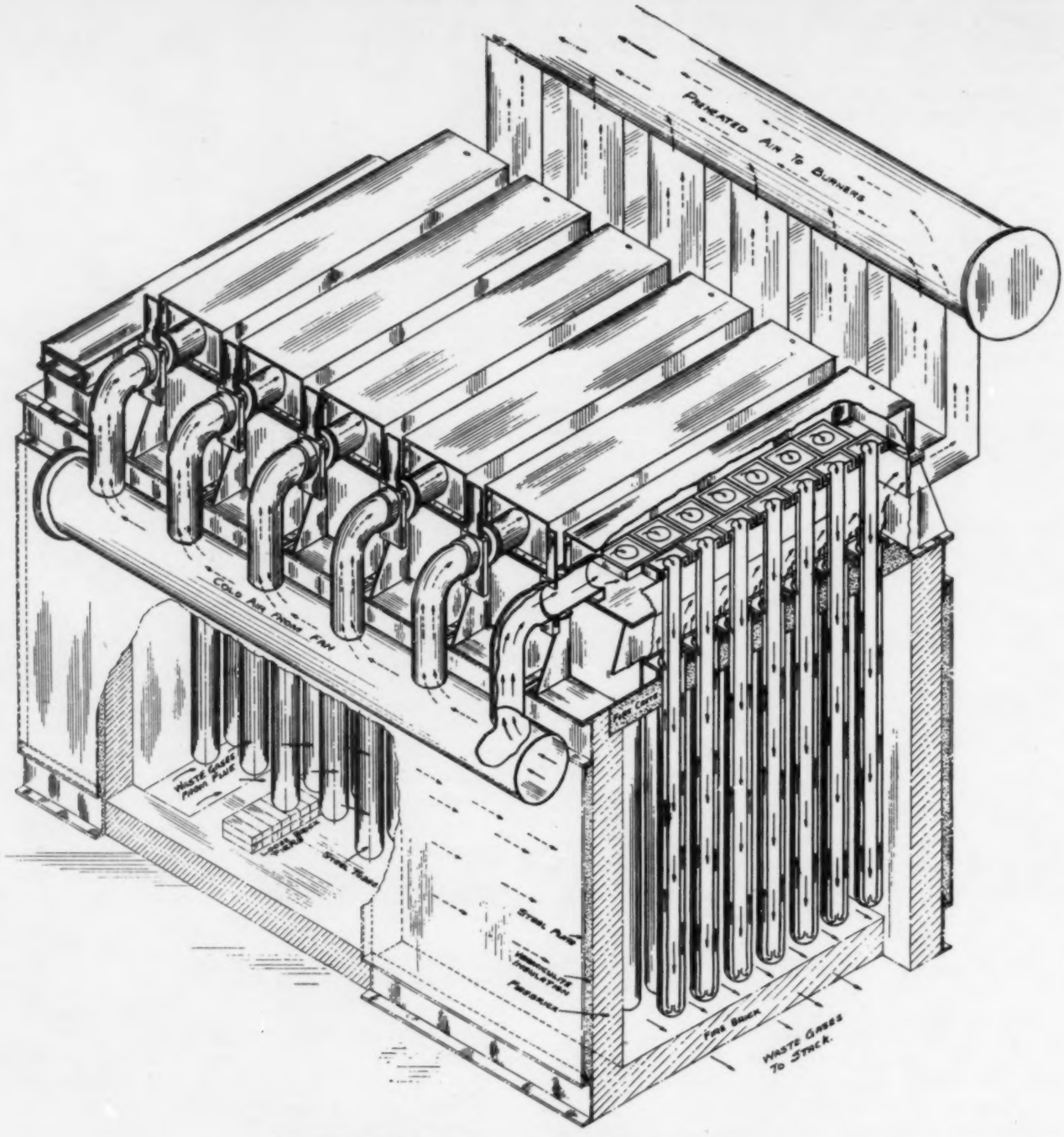

12" O.D. ROLLS ON 12½" STAND CENTERS
RATIO OF TUBE AREA
1.04
1.15
PROCESS TIME = .21 SECONDS
INITIAL LENGTH OF ENTERING TUBE PROCESSED BEFORE TENSION IS APPLIED.
LENGTH OF TUBE SUBJECTED TO NON-UNIFORM TENSION BY UNSTABLE SPEED RATIO OF 1ST AND 2ND STAND.
200 R.P.M.
TENSION APPLIED BETWEEN 1ST AND 2ND STANDS, BUT CONSTANT SPEED RELATIONSHIP NOT YET ESTABLISHED.
1.16
PROCESS TIME = .39 SECONDS
STABLE SPEED RATIO ESTABLISHED BETWEEN 1ST AND 2ND STANDS.
PROCESS TIME = .62 SECONDS.
STABLE SPEED RATIO ESTABLISHED BETWEEN 2ND AND 3RD STANDS.
1.13
PROCESS TIME = .81 SECONDS.
STABLE SPEED RATIO ESTABLISHED BETWEEN 3RD AND 4TH STANDS
1.10
PROCESS TIME = 1.0 SECONDS
STABLE SPEED RATIO ESTABLISHED BETWEEN 5TH AND 6TH STANDS
1.00
PROCESS TIME = 1.37 SECONDS
TOTAL AREA REDUCTION = 2 TO 1
560 F.P.M.
CROP END LGTH. = 30"
THEORETICAL LGTH. OF HEAVY WALL SECTION = 48"
1 2 3 4 5 6 7
STAND NUMBERS
LENGTH [12" TO 18"] SUBJECTED TO SUFFICIENT TENSION TO PRACTICALLY EQUAL NOMINAL WALL SECTION

The progress of a tube through 7 stands of a 16-stand, stretch reducing mill is shown in this chart.

on the process. The zinc distillation must also be done in an atmosphere which is free from oxygen, carbon dioxide, and preferably from carbon monoxide. Power requirements are less than ½ kilowatt per pound of zinc recovered, and in one case the labor amounted to about 1¼ man hours per ton.

The disposal problem for waste pickle liquor is yet to be solved, although much research and experimental work was done during the past year. Approximately 90 per cent of the steel which is pickled is processed in dilute sulphuric acid and both batch and continuous processes are used in the continuous pickling of steel. The research work now in progress indicates that a practical process may be in sight, but much development work must yet be done before the goal is accomplished. Most of these processes, however, are such that the economics require the work to be done on a very large scale. This in some cases, requires extensive systems, and in others, where the economy of the process is dependent on the sale of the waste products, require large markets for this waste product which are not now in existence.

The process which offers most promise at present in waste pickle liquor disposition is one in which the pickle liquor is combined with coke oven ammonia, another waste product. The sulphate ion in pickle liquor is substituted for the sulphuric acid which is normally purchased for making ammonium sulphate. The iron in the liquor is converted into an oxide for charging into the blast furnace. Final economic evaluation awaits study on a semi-commercial scale. This process is feasible only for large scale operations.



Schematic sketch of improved, metallic recuperator.

FURNACES AND CONTROLS

New development work in furnaces and controls during the past year was primarily concerned with the adaption of open hearth furnaces to combustion with enriched air or oxygen, and most of this has been covered in the steelmaking section of this report. However, the effort to increase the production has seen the introduction of high speed gas heating furnaces into the seamless tube production line, and one such unit installed in a seamless tube plant indicates good possibilities can be realized from such units. Among the advantages are reduced operating cost and better output and quality. One of the main factors in the reduction in operating cost has been the reduction in fuel cost from $1.26 to $0.46 per ton of tubing in the heating for the final sizing operation. The units which accomplish this are continuous tube heating units, gas fired. The efficiency is primarily due to the use of ceramic gas furnaces which utilize carbureted gas-air mixtures at high pressures. Production speeds are rated from 50 to 150 fpm for 4 in. outside diameter tubing and 54 to 162 fpm for 6 in. outside diameter tubing.

Another similar development in this field is a new

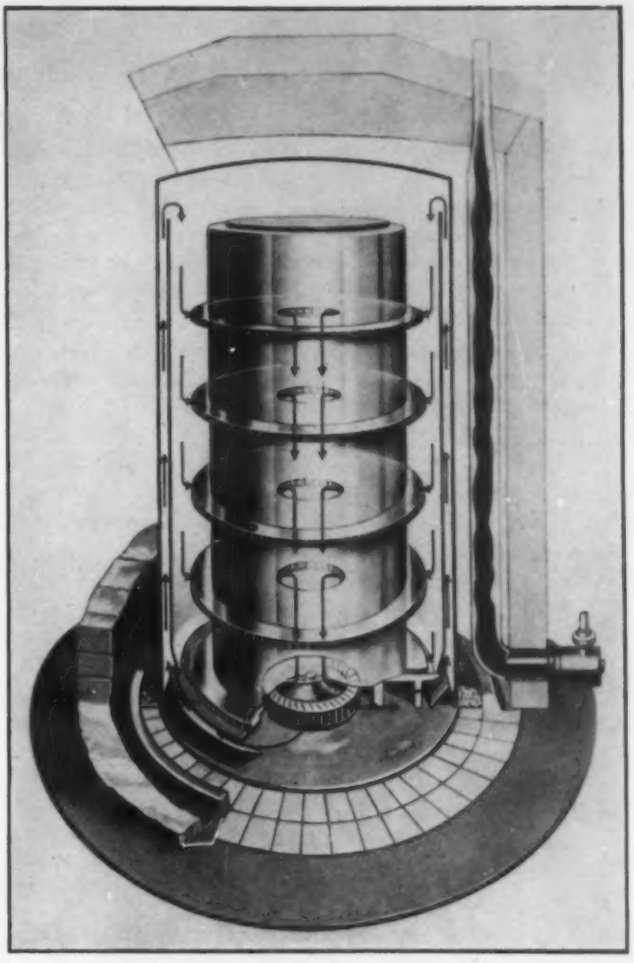
gas-fired, continuous roller hearth furnace for high temperature annealing. Features of this furnace are silicon carbide radiant tubes and conveyor rolls. The furnace is used to anneal welded stainless steel tubing ranging from ¾ to 3 in. outside diameter. This furnace also enables heavy roller loads to be conveyed through it either in batches or continuously. The flame length of the burners can be controlled to give even heating for the entire length of the tube, and tests have shown that in a furnace 22 ft long, a temperature can be held to a plus or minus of 10 F, thus insuring even heating of the charge. The effectiveness of the rollers is due to the fact that silicon carbide has the property of having its maximum strength at about 2500 F.

The radiant convector type annealing units for handling large diameter tin-plate coils showed increasing usage this past year. These units apply the heat to the coil edges rather than transversely through the laminations, and this enables the heat to be transferred three to four times faster than in the normal method. Coils can be saturated in about 17 hours compared to about double that time with the normal method, and with greater uniformity in temperature between outside and inside coil than is achieved by the old method. In such an installation recently constructed in Canada, standard gage tin plate is coiled on 20 in. arbors to make coils weighing 11,000 pounds each. The furnaces are designed to permit eventual loading of 54 in. diameter coils. The present 11,000 pound, 46 in. outside diameter coils give a production rate of 2.8 tons per furnace hour, with two-stack units, annealing tin plate at 1180 — 1200 F with 8 coils per charge. The cooling time is about 18 hours, which is 2 — 3 hours longer than the heating time. Heat is applied to the edges through circulating the gases under the inner cover by means of a large impeller type fan located under the bottom of the stack of steel coils. Compensating convectors or separators are placed between the coils so that the hot gases circulate between the coil edges and the inner cover. This improves the convection transfer of the radiant heat which is supplied by the radiant heating tubes in the furnace bell.

One installation completed during the year was that of a battery of air-fuel ratio controlled oil-fired soaking pits. This installation eliminates checkers, regenerators and recuperators. The products of combustion are introduced into the pit rather than elements of combustion and a controlled neutral atmosphere surrounding the ingots is maintained at all times as a result of this procedure. The burner is so proportioned that combustion starts at the burner end of the combustion tunnel and is practically completed within the tunnel, and because of this, the ingots heat evenly from side to side and there are no hot spots because of the impingement of exploding fuel. Hot layers due to oxygen stratification are also eliminated, and because of the neutral atmosphere decreased scaling is a result. Fuel requirements in the units are approximately 11.4 gal of oil per ton of ingots. Btu content of the oil is approximately 150,000 per gal.

A development in carburizing furnaces enables the operator to hold a charge in the furnace indefinitely without damage or ultimate change in the material. This has been accomplished in continuous gas carburizing, which enables furnaces to be operated over the week end without shutdown. The result is accomplished through furnace design and proper manipulation. Since case depth and carbon gradient are functions of time, it is reasoned that if the temperature is reduced to such a point that absorption and diffusion of carbon is practically nil, and when the carburizing medium is of such a nature as to be practically neutral, time is not a factor in the process. In order to attain this end, the changes in furnace design which are required include two low arches, one at each end of the cooling zone, to facilitate the removal of heat in the cooling zone without affecting the other zones. It is also necessary to move the carburizing gas inlet ports toward the charge end of the furnaces to avoid undue sooting of the work in the zone. An auxiliary blower is also installed to accelerate the cooling rate in the third zone. The factors which determine whether the process can be applied to a continuous furnace are that a combination of atmosphere and temperature must be available which will prevent carburizing and diffusion reactions wherever work is present in the furnace, and a high temperature must be maintained in one zone to avoid explosion hazards. Furnaces which are constructed to provide control of temperature and composition of atmosphere to obtain any desired range of case characteristics can be utilized.

A new reasearch laboratory furnace has been developed which is capable of producing heats of 3100 degrees



A stack of coils being heated by the radiant convector principle is shown in this phantom view.

F which is about 200 degrees F hotter than any ordinary laboratory furnace, and this furnace has an effective heat zone of about 4 cu ft which is a good bit larger than usual. The difference in design of the furnace from the conventional is that heavy molybdenum rods are laid on ledges in the refractory brick, instead of using heating elements consisting of fine wire coils on muffles.

A combustion chamber for heavy fuel such as Bunker C oil has been developed which is small and efficient, has long life and is free from carbon deposits and hot spots. Fuel can be ignited readily and the flame is stable under a wide variety of loads. At present, its application is in gas turbines. It consists of a stepped, nickel-chrome steel tube about 36 in. long, and varying in diameter from 3 — 4½ in. Heat release is about three million Btu per cu ft per hour atmosphere of pressure, which is about 15 times as much as for steam boilers. Although the flame temperature is 3500 F, the combustion-chamber sleeve is about 1000 degrees and this is due to cooling air between the stepped sections.

A new atomizer type water-cooled burner equipped with adjustable atomizers for manufacturing fuel in a fine spray is now being manufactured. The result in efficient combustion reduces the time required for melt-down. This burner operates accurately, and any liquid or gas fuel can be used.

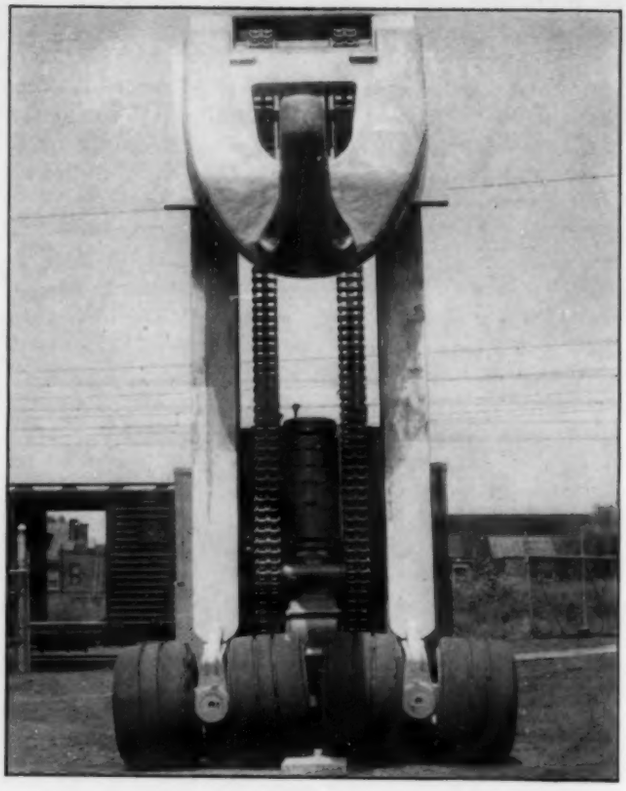
Because the increased cost of fuel makes recuperators relatively more economical, there is a greater tendency for their use on new installations. The metallic recuperator is finding increased use also, and installations are paying for themselves in a relatively short period of time. The use of such recuperators enables high air pressures which provide increased heat transfer rates. Units are designed so that component heat-treating elements can be raised for inspection and cleaning. The use of sheets makes possible a thin metal gage which increases heat transfer rates.

A pneumatic temperature measuring system for measurement and control of very high gas temperatures up to 5000 degrees, Reaumur, has been developed. This instrument is a gas thermometer utilizing the density of the gas being measured as a direct indication of the temperature. It has the advantage that it is not subject to the usual radiation effects common to present temperature sensing methods, and can be applied also where only small quantities of the gases are present. Accuracies for these instruments are plus or minus 1 per cent to 2500 degrees R, and plus or minus 2 per cent from 2500 — 5000 degrees R, with a response rate of ½-second or less.

One product which would be valuable in maintenance work is a new air setting refractory cement which sets with little shrinkage. This material still combines all the requirements required by the brick mason, and has maximum workability, and can be trowelled directly from the drum after many months of storage. The material sets to form a tight, dense, joint capable of withstanding abrasion, slagging, and spalling as effectively as the brick itself.

MATERIALS HANDLING

The problem of charging scrap into the open hearth becomes ever more difficult. The increased proportion of light scrap in recent years requires a larger number of boxes to handle the same amount. The use of oxygen in the open hearth, if adopted, will increase the charging time from about one-sixth of the total time to one-third, and charging time is thus a much more important factor in operations.



This ram truck has a capacity of 75,000 lb. One design feature is an articulated trailing axle.

If the increased pressure for production leads to the use of oxygen, this change cannot alone increase production as the average steel plant is a fairly well-balanced unit, and to increase production, it may be necessary to increase capacity of a number of steps in the production cycle, and one of the steps which may be a bottleneck is that of charging scrap. With the normal furnace door, charging boxes, in general, can be increased but little over their present capacity due to limited clearances.

One machinery manufacturer is now studying a solution of the problem in which the charging will be done in a single charge requiring only about six minutes. An essential requirement for this is an open hearth with a removable front, and this is available. The charging pan will have a floor area similar in size to the furnace. In charging the furnace under this plan, the front is removed, the cradle and loaded pan are run into the furnace. Retraction then starts and while being retracted, the pan floor rolls underneath the pan frame depositing the charge uniformly on the furnace hearth.

The speeding-up of strip mills also increases the material handling problems of such mills. The new mile-a-minute strip mill at the Weirton Steel Company, in order to best handle the coils, installed what is probably the only conveyor system of its kind. Below

the floor level of the 66 in. hot mill and adjacent pickler building runs a conveyor which consists of 126 small flat cars that are coupled together on an endless oval track. The distance from end to end of the oval is 300 ft, and the distance around the oval path of the conveyor is 636 ft. Coils remain on the conveyor for an average time of about 2 hours, and during this time the coil temperature drops from 1000 — 1200 F down to 200 — 300 F. Electric control starts and stops the conveyor automatically, and each time it stops one coil is loaded at one end and one is unloaded at the other end.

Speeding up of strip mills makes it more economical to handle larger coils, and the desirable size of such coils is in some cases greater than the capacity of industrial trucks which are being produced. This demand may be met, however, with the larger trucks now under development, and plans have been completed for fork and ram trucks with load capacities up to 60,000 lb.

Of interest to tin-plate manufacturers is a clamp attachment developed for handling tin plate. This is in the form of a clamp attached to an arm pivoted at the top of the heels of the forks. The lift chain mechanism is attached to the rear of the pivoted arm, and the weight of the load closes the clamp, preventing loads from vibrating out of alignment. When no load is on the truck a spring keeps the clamp open.

The use of pallets in stacking is finding increasing use, and lift trucks are available with lifts up to 220 inches thus making increasing use of available vertical space.

A vibrating screen is available which can be used in sizing of iron ore, as well as open hearth and blast furnace slag, fluorspar, and stone. This screen is known as a concentric-action-screen and can be had either floor mounted or suspended by spring and cable. The screen is made in double or triple decks, and in sizes from 3 × 8 to 6 × 14 ft.

MECHANICAL DEVELOPMENTS

Mechanical developments in the industry were concentrated more on design and manufacturing refinements than on radically new procedures. However, a number of trends in mechanical development are beginning to become apparent.

One item in which there is a great deal of interest is the possibility of using gas turbines in power stations. Gas turbines are based on an old principle, but previously were not practical due to the lack of material which could stand up under the severe operating requirements. Development of new alloys and materials has made the machine a practical proposition, and such installations are being widely used in aircraft, and to some extent units are being used in steam locomotives. The trend in modern times to plants, in which plant steam demands are decreasing and condensing power demands are increasing, gives to gas turbine installations an economic advantage which they did not have before. A gas turbine power plant would probably consist of a turbine, a compressor, a generator, a waste-heat boiler and economizer, a fuel system for gas and oil, a turbine combustion chamber, a boiler combustion chamber, and a reducing valve for reducing steam from main-header pressure to deaerating-heater pressure. Since the gas turbine itself will have an efficiency of

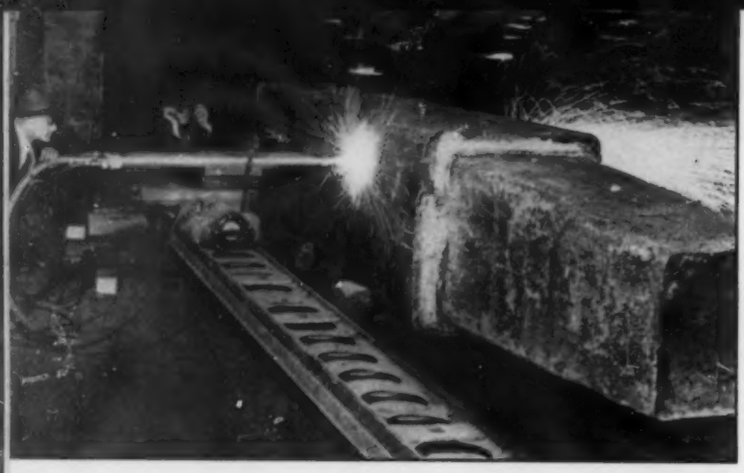
Powder-scarfing stainless ingot.

approximately 86 per cent when the steam in the turbine is 1200 F, the overall efficiency of such a gas turbine plant with 150 psi waste heat boilers would be about 59 per cent. Compared with this, the efficiency of a 600 psi extracting and condensing steam plant would be about 51 per cent and a 400 psi condensing plant 46 per cent. These comparisons have been based on design calculations of a typical industrial power plant capable of generating 5000 kw per hour at 80 per cent power factor at all times and an annual average power demand of 4000 kwhr. The annual average factory steam demand is 50,000 lb per hr of 150-psi saturated steam or its equivalent in superheated steam at the same pressure. The comparative efficiency shows that the turbine does have possible advantages, particularly in the case of extracting or condensing plants.

Tests on a 2000 hp experimental gas turbine have been completed and these have shown no difficulties. This unit has been run better than 600 hours, including 100 hours at full load and 300 hours of cyclic operation and with the full design temperature of 1350 F. There has been no evidence of creep or distortion difficulties, nor have there been any signs of oxidation. New units are to be built which will probably use temperatures another hundred degrees higher.

Developments in mercury-vapor plants are also to be expected. The problem of wetting of steel surfaces by mercury has been solved by the use of a mercury-sodium-titanium amalgam. Magnesium can also be used instead of the sodium in the amalgam. The mercury cycle lends itself well to the construction of standardized design.

In steam plants, the upward curve on steam temperatures has now hit 1000 F and one such plant has been constructed. Steam temperatures as high as 1400 F have been used in some superheaters. The use of standardized packaged plants is finding increasing use.



This blowpipe can cut up to 66 in. thick and reverses the usual theory of using higher oxygen pressures for thicker cuts.

A new development in the burning of low-grade, high volatile, and high ash coals without pulverizing is a so-called "cyclone" burner for burning crushed coal in suspension. In this burner, crushed coal and carrying or primary air are fed tangentially at high velocity through the coal inlet. Particles of coal are thrown to the surface and carried along in an increasing helical pitch path. Sufficient air for combustion is admitted at high velocity parallel to the coal stream. The unit shows good combustion with a minimum of excess air — the latter as low as 8 per cent but usually about 13 per cent, with a great reduction in fly-ash emission. Unburned carbon loss is about 0.1 of 1 per cent.

Much has been written about development in atomic energy, but from the standpoint of the steel plant, the use of atomic power is probably well in the future. At present, the economics of an atomic power plant do not compare with that of a coal or oil burning plant, although the difference in the cost of producing power from nuclear energy and from coal is relatively small. One important feature, however, is that the use of such energy provides us with large resources of overall energy, for uranium is far from a rare material. However, no one has yet proposed the use of atomic energy as a substitute for coal in the coke plant.

One very new development is the use of sonic waves as a precipitator of carbon black and this method can be used for other materials. Sound waves successively compress and rarify the air. Small particles tend to follow this air movement and larger particles remain relatively still. Under proper conditions, the dust particles adhere to each other and form aggregates with as many as several hundred primary particles which can be collected in a standard separator. In general, the finer the particles, the better the action, and the best field of use occurs when dust particles are smaller than ten microns.

Supersonic inspection, mentioned in this report last year, is finding increasing use; and among these the supersonic reflectoscope is being used for the inspection of rolls up to 18 ft long.

Another variation in sonic instruments is the automatic sonigage. This instrument can be used both to detect flaws and also to measure thickness with less than 2 per cent error. Thicknesses from 0.005 — 0.250 in. can be read directly and up to several inches indirectly.

The spectrograph is finding increased use in analyzing melts. The old method of photographing the spectrum and comparing the lines (the slow part of the process) has been changed by a new development so that the photographic negative is replaced by electric impulses.

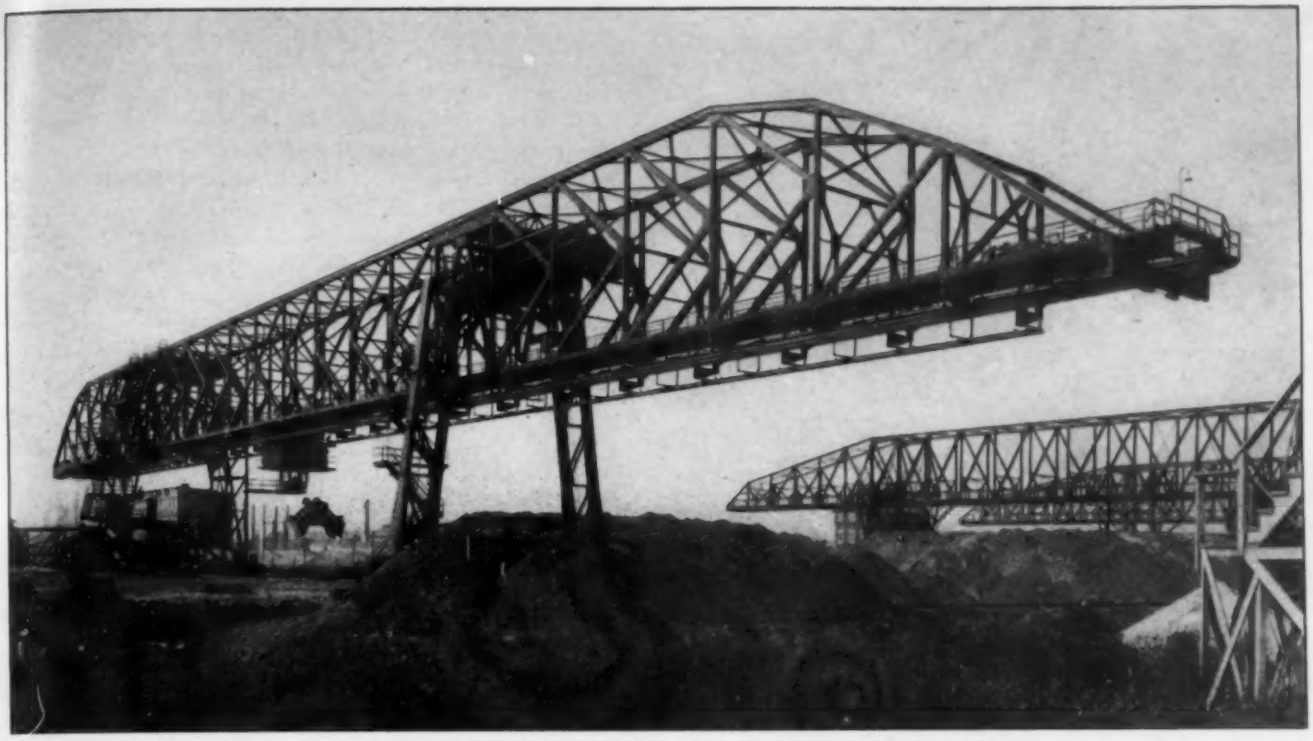
One spectrographic installation was set up to use a-c current for the arc, thus saving conversion equipment, by adding a magnetic coil, surrounding the carbon electrode, and energized at 100 volts d-c. A diaphragm with $\frac{1}{8}$ in. aperature and condensing lens effected much improvement in eliminating excess light. Standard procedures and emulsions helped speed up operation, as well as standard charts when method was used as a control.

The outstanding use of the spectrograph as far as the steel industry is concerned is the ability to make analyses of heats before the heat is tapped and in time for required corrections to be made. It has been estimated, for example, that the direct reading electrical type of spectrograph can save $100 per melt of electric furnace time, and handle up to ten furnaces. The actual time for a quantitative analysis of eight elements can be obtained 40 seconds after the specimen has been put in the electrode holders.

A new inspection method using the magnetic principle has been developed. The basic principle is the use of an electromagnetic pickup coil, sensitive to magnetic leakage caused by flaws in the steel magnetized by the electric current. An electrical recorder is used to replace the magnetic particles of the magnaflux method. Cracks in bore surface of tubes, as well as on flat, accessible surfaces are easily detected, and chart records can be easily made. The instrument can also be adjusted to pick up cracks only above a specified size.

One development in mining ore is a new method in making vertical blast holes called fusion piercing. In this method, a hot flame (4000 F) produced by burning oxygen and a flux bearing fuel in a drill head causes some rocks to flake and spall off, and others to melt. The gas pressure forces the molten material up and past a water spray, quenching and breaking it up, and

A broken frame for a 250 ton press is being repaired by insertion of metal interlocks.



Welded construction was used throughout this ore bridge in all but the superstructure.

the material goes out of the hole in the space surrounding the drill stem.

Tests on the fusion piercing method give results in which 6 in. diameter holes in taconite were made by fusion piercing at an average rate of 10 ft per hour up to 30 ft deep. This compares with a speed of about 1 ft per hour for drilling holes of similar diameters.

A new heavy-duty oxy-acetylene cutting blowpipe developed recently can cut steel ranging in thickness from 16 — 50 in. and is particularly suited for hot-top cutting, ingot slitting, riser cutting, as well as cutting large forgings and scrap where previously the oxygen lance was required. This torch is water-cooled and is intended to be mounted on a heavy-duty, straight-line cutting machine. Oxygen pressures are never over 35 psi.

A powder-cutting process makes possible cutting of stainless steels which previously have been difficult to cut or scarf because of the chromium and nickel content of these materials. The process consists of blowing a powder into the oxygen stream from outside of the nozzle preheat flame when cutting; and in scarfing the powder is drawn into the oxygen stream within the nozzle. The powder is heated to ignition temperature and burns in the oxygen stream to create an extremely high temperature reaction. The heat of this reaction enables cutting and scarfing to start without waiting for a preheat period, and during the reaction the refractory oxides are continuously removed by a combination melting and fluxing action. The apparatus required for the process is both simple and inexpensive.

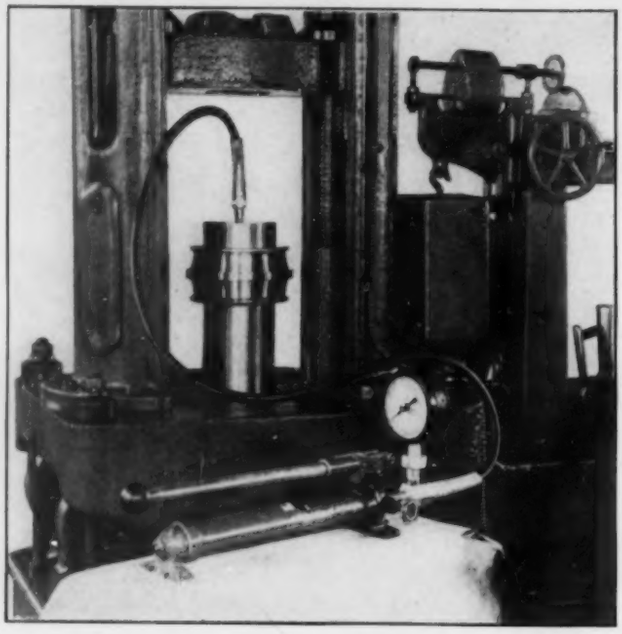
A new method of storing gas underground has been been developed by one of the steel companies. Storage units consists of 24 in. seamless molybdenum steel pipe 40 ft long, with wall thickness of ½ in. Capacity of the units is 25,000 cu ft at 2240 lb pressure, and they are buried about 5 ft underground. Batteries of these units have been installed at several locations.

A new method for mounting bearings and couplings incorporates the use of an oil injection device by which pressure can be applied internally to disassemble the unit. The use of such a device therefore permits tighter fits and greater interferences than would be normally allowable in design, and with consequent elimination of the use of keys or working in the joint.

A new 15-ton ore bridge recently constructed had all-welded legs, trucks, and trolley. The procedure gave erection advantages and an economical and sturdy bridge. There is greater rigidity in the joints, and this rigidity permitted the use of somewhat smaller sections. Maintenance should also be less.

An ingenious mechanical repair system which has been developed is a method of salvaging machine parts without the use of welding, with a joint efficiency which is as strong if not stronger than the original section. This method enables repairs to be made without distortion and without patches. The application of the process entails the insertion of a prefabricated alloy lock of precise dimension into a prepared aperture in the parent metal. These locks are made in various sizes and depths. The strength of the alloy lock is greater than the cast iron or cast steel which is being repaired, and when properly designed, the repaired section is stronger than the original. Variations in the locks are available for various types of repairs. The variety of locks are such that they may be used to solve repair problems of almost any kind.

In the lubrication field, the barium base lubricating



The oil injection method is here being used in a test set-up for dismounting a cylindrical bore ring.

bases have been developed to the point where there is now available a grease which is both water and heat resistant. The resulting grease also has enough cohesion so that it does not drip, yet maintains its consistency, and is soft enough so that it can be pumped with ordinary grease guns at temperatures as low as 35 F. The melting point is above 400 F.

ELECTRICAL DEVELOPMENTS

The power generating industry is now seeing a boom of record proportions. Manufacturers have orders for almost two billion dollars worth of generating equipment which will be enough to boost the nation's electric power production capacity about 15 per cent. At least three years will be needed to fill the orders on hand. In terms of kilowatts, this means that about 13 million kilowatts are on order, of which probably not more than 20 per cent are for replacements of capacity now produced by obsolete equipment. About ¾ of the capacity now on order is for business-managed public utility companies and the remainder will go to government-owned and private industrial plants. The additional capacity may involve some removal of old equipment in order to use space, but the majority will be left in place for reserve. Shortages of all types are, however, hampering and delaying deliveries of this equipment.

The turbines in these plants are essentially similar to the older ones, but in general, the turbine generator of tomorrow will be operating at higher pressures and temperatures. The trend in the large units is to the use of a 3600 rpm hydrogen-cooled generator. The hydrogen pressures are going higher, and some installations contemplate raising this pressure to as much as 15 psi.

Standardized turbine units are becoming a greater proportion of those made and, at the present time, two out of every three new turbine generators are of the standardized variety. A large number of the new turbines are rated as 850 lb gage, 900 F and some go as high as 1250 psi gage, 950 F.

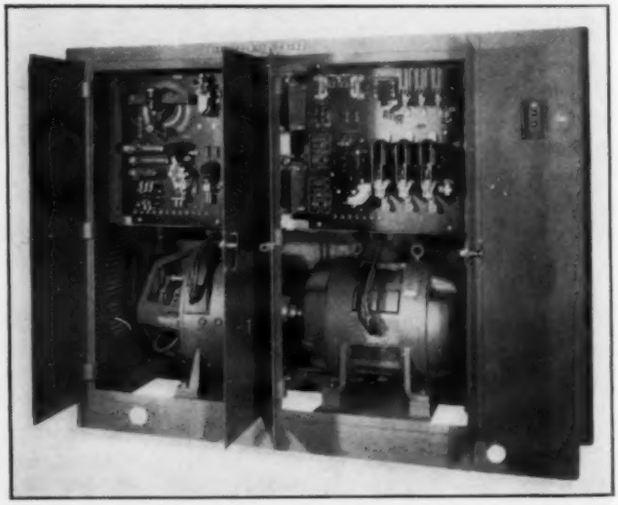
Developments in switchgears are following two lines, the continued improvement of oil blast circuit breakers and the development of the air blast type of breaker. Switchgears have been improved to the point that alternating current circuits of almost any capacity can be interrupted. The a-c circuit breaker is dependent in its operation upon the periodical occurrence of zero current which represents a natural means of deionization. D-c breakers have no such point of zero current and therefore the problem of interrupting d-c circuits is a much more difficult one. A great deal of work has been done in the development of vacuum type breakers for d-c circuits, and this work has demonstrated that a very high vacuum is effective in aiding the interruption of direct currents; but such breakers are not yet able to compete in high power circuits.

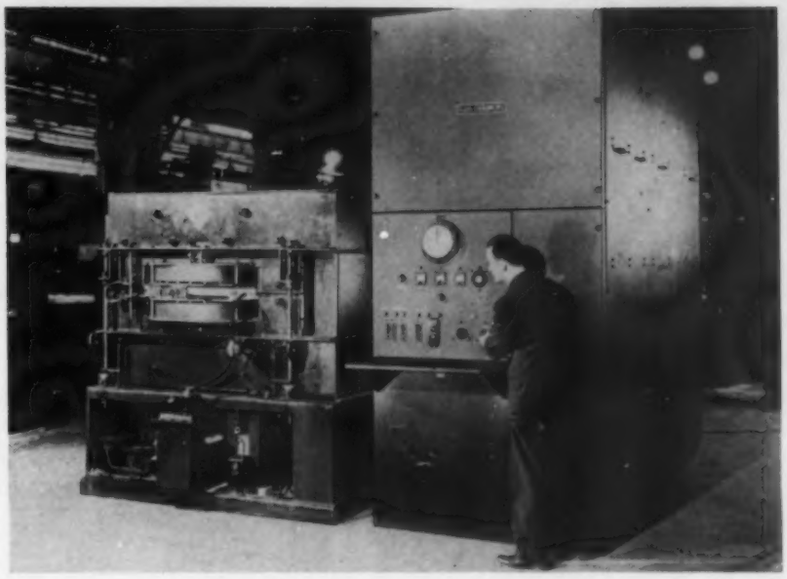
A new, small, high interrupting capacity protective breaker has been developed for use in the larger sizes of distribution transformers, and this breaker raises the rating ceiling for several distribution transformers. The transformers on which it will be used can experience, theoretically, maximum short circuits of 8500 amperes. The complete single-phase breaker is only six inches square by eight inches high. Thus self-protected transformers are now possible in 37½ and 50-kva ratings, using the new single breaker instead of the two previously required.

A unit has been built which allows transformer oil to recondition itself continuously while the unit is in service. This unit consists of a cylinder of activated material which is mounted on the transformer tank through which the oil circulates by natural thermosiphon action. Several years of experimentation have shown that the system is efficient in removing moisture and other agents that decrease the dielectric strength of the oil.

The trend to high capacity transformers with higher ratings and yet, at the same time, holding such units within shipping and handling limits is still continuing. The largest units now shipped are rated at 50,000, 66,667, or 83,333 kva, depending on the cooling system

Spot conversion equipment can now be supplied in package units.





On the left is a betatron and on the right is its control panel. Rays will penetrate steel up to 24 in. thick.

used. These new transformers, however, do not deviate from established practice, and are being used in utility construction. Features are shell-form construction which enables the tank wall to be placed close to the core and coils, and cores of grain-oriented steel, which give ⅓ better permeability in the direction of the grain, and mean less iron in the magnetic circuit.

The trend to take advantage of better motor design with the consequent ability to put the motors in smaller frames still continues. The new AISE d-c mill motor standard, adopted in September 1947, is an example of this trend. The new AISE standard provides a new line of mill motors in which each rating has been put in what was the next smaller frame size. Thus by holding mounting dimensions constant, installation problems have been simplified, and the new motors can also be used to replace directly presently overworked motors.

Another feature in motor design which will enable the construction of smaller motors is the use of copper fins extending from the stator core to improve motor cooling. As a result of this principle, a whole new range of motors has been developed which run from 125 to 1000 hp. The design is based on the premise that when copper punchings are spaced at intervals between the steel laminations, the copper which is in intimate contact with the steel will conduct heat accumulated in the laminations from the interior to the exterior of the motor, where the circulating air removes this heat to the outside.

One trend in the use of motors in tandem steel strip mills is that of using an individual generator to supply each motor. This is justified because the horsepowers required in the single motors are becoming so sizable, and because of the resultant simplification in control such as elimination of IR-drop compensators.

The largest diameter synchronous mill motor ever built was recently installed in a southern steel plant. This motor is a 4000 hp, 78.3 rpm, 6600 volts, 3 phase, 60 cycles, 0-8 pf, 92 pole and will be used for the continuous drive of a secondary roughing stand on an existing 48 in. hot strip mill that is being improved to give increased production.

The single-phase induction motor has been improved during the past year, and the results should give fewer troubles and less maintenance. Starting torque characteristics have been improved to the point where it can compete with the repulsion-start, induction-run motor. The new motor has high torque values all the way from standstill to full speed. This motor is a capacitor start motor and is electrically reversible. A centrifugal switch of improved design is used on motors rated up to 5 hp, and on higher ratings a newly developed relay is used.

A recent announcement describes a 180-kvar shunt capacitor, which is factory assembled with breaker and relays for voltage or current control. This unit is designed for operation on 2400-volt delta or 4160-volt wye distribution circuits. Such units are available without the voltage and current control features and can be equipped with manual or time-switch control.

One method of operating d-c motors on a-c lines is by the use of a controlled tube-type rectifier. This unit gives a wider speed range and closer control than the selenium rectifier. Although the unit is several years old, improvements in design have reduced the number of tubes required for certain sizes and substitutes industrial-type components in place of radio type. One new use for this unit is in steel mills in driving alloy strip through annealing furnaces and pickling tanks. The power requirements for this operation are small, 3½ — 7 hp, and the speed must be adjustable and closely regulated over a wide range, much more than possible by field control of a standard d-c motor. The new unit gives precise speed control over the 4 — 32 fpm speed range of the processing line, and a 2½ — 1 speed adjustment as the strip is wound up on the reel. With both field and armature control, the speed range can be varied 20 — 1.

A development in reversing mill d-c generators is the use of a laminated steel frame instead of the conventional solid frame. The resultant effect of this change is a reduction in sparking during transient load changes.

The betatron is finding practical application in the industry and a 20 million volt betatron is in operation for the production of x-rays. One such unit can penetrate 20 inches of steel in 20 minutes and detect flaws of extremely small dimensions.

Perhaps one of the outstanding developments in crane control is the use of a new alternating current control

This full vision crane cab on a stripper crane also is air-conditioned.

system. The new system uses an eddy-current clutch or brake, and on the crane the unit acts as a brake. Speed control characteristics of the installation are flat in both the lowering and raising directions, and sufficient torque is developed by the hoist motor on the first step of the control so the load will always raise within the capacity of the crane, which latter is a new feature for a-c control schemes. The unit acts as a brake to provide a load on the a-c slip ring motor which ordinarily has no speed regulating properties under low or light load conditions. The brake is mounted on the motor pinion extension shaft. The rotor requires no electrical connections, and because of this fact coupled together with the fact that the field poles are stationary, there are no electrical moving parts. The brake torque is accomplished through magnetic lines of force between the stationary poles. The unit is so connected that failure of the current in the unit would result in operating a current relay disconnecting the unit from the line and setting the motor brake. When the descending load overhauls the hoisting unit it starts generator action to excite the magnetic torque unit thus slowing the hoist. This generator is open circuited under normal operation and is inserted in the circuit only when the main line disconnect switch is open or in the case of power failure. This dynamic braking feature gives the same safety as the d-c dynamic braking circuit.

For operation of cranes which are apt to tip over, a warning device has been developed which indicates when the crane is overloaded. A magnetic strain gage is used which is attached to the boom. Then when the boom is overstressed, a light or bell warning is flashed into the operator's cage by means of an electrical control.

A new combination service and parking brake in the 8 in. × 3 in. size for light industrial cranes has been recently put on the market. Previously, this size brake was constructed only as a hydraulic service brake.

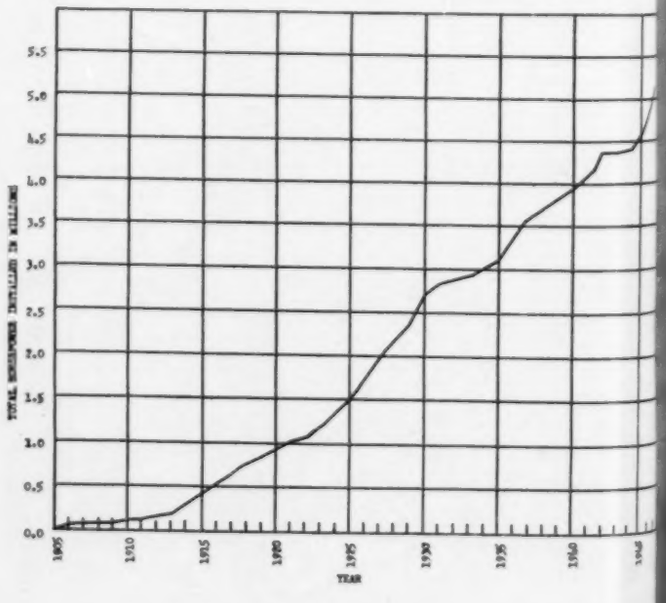
An all welded magnet which has been designed has a number of advantages because the welding eliminated the recesses for the pole shoes thus giving better coil space and a more effective magnetic power. In addition, there is no loosening of any of the parts or any crevices where dirt can collect.

Uses for silicone products are increasing and a new one is a silicone rubber, which is produced by compounding a silicone gum with suitable fillers. This silicone rubber has the ability to retain its flexibility, resiliency and surface hardness over a range of temperature from — 70 F —+500 F, over long periods of time. One factor which must be considered in the use of the material is that the properties at room temperatures are not equal to those of natural or synthetic rubber, and therefore the material cannot be merely substituted for existing designs.

Glass fiber materials are finding increasing uses and many manufacturers have adopted the yarn for their standard textile for the outer braid of cable. The material cost is cheaper, and the problem which has existed up to now of forcing the compounds to adhere to the iron has been recently overcome.

An extremely small diameter glass fiber gives promise of being a very versatile insulating material which can be used at temperatures up to 1800 F.

The cumulative curve of main drive motors over 300 hp shows a total to January 1, 1948 of 5,128,290 hp. One hundred forty-five motors (233,175 hp) were added in 1947.



ELECTRIC MOTORS OVER THREE HUNDRED HORSEPOWER

APPLIED TO MAIN ROLL DRIVES IN THE IRON AND STEEL AND ALLIED INDUSTRIES DURING 1947

Item	Horsepower	Revolutions per minute	Volts	Frequency	Method of drive	Kind of mill	Purchaser	Location	Manufacturer
1	300	400/1000	600	d-c	Geared	28 x 66 in. Skin pass mill	A. R. B. E. D.	Luxembourg	General Electric
2	300	400/1000	600	d-c	Geared	28 x 66 in. Skin pass mill	A. R. B. E. D.	Luxembourg	General Electric
3	300	400/1000	600	d-c	Geared	Tension roll	A. R. B. E. D.	Luxembourg	General Electric
4	300	400/1000	600	d-c	Geared	Tension roll	A. R. B. E. D.	Luxembourg	General Electric
5	300	375	380	50*	Geared	Sheet mill	Acero Del Pacifico	Chile	General Electric
6	300	225/675	600	d-c	Geared	Rod mill	Colorado Fuel and Iron Corporation	Pueblo, Colorado	General Electric
7	300	300/750	600	d-c	Geared	Rod mill	Colorado Fuel and Iron Corporation	Pueblo, Colorado	General Electric
8	300	300/750	600	d-c	Geared	Rod mill	Colorado Fuel and Iron Corporation	Pueblo, Colorado	General Electric
9	300	300/1200	250	d-c	Geared	56 in. Skin pass reel	South African Iron and Steel Industrial Corporation, Limited	South Africa	Westinghouse
10	350①	200/500	250	d-c	Direct	60 in. Temper tension rolls	Carnegie-Illinois Steel Corporation	Gary, Indiana	Westinghouse
11	350①	200/500	250	d-c	Direct	60 in. Temper tension rolls	Carnegie-Illinois Steel Corporation	Gary, Indiana	Westinghouse
12	350	550/1100	330	d-c	Geared	Flanging mill	Lukens Steel Company	Coatesville, Pennsylvania	General Electric
13	350	225/625	600	d-c	Direct	Rod and skelp mill	Acindar Industria Argentina de Aceros, S. A.	Argentina	General Electric
14	350	225/625	600	d-c	Direct	Rod and skelp mil	Acindar Industria Argentina de Aceros, S. A.	Argentina	General Electric
15	400	250/1000	250	d-c	Geared	84 in. Temper entry reel	Carnegie-Illinois Steel Corporation	Gary, Indiana	Westinghouse
16	400	300/1200	250	d-c	Geared	60 in. Temper entry reel	Carnegie-Illinois Steel Corporation	Gary, Indiana	Westinghouse
17	400①	500/1000	600	d-c	Geared	60 in. Temper mill	Carnegie-Illinois Steel Corporation	Gary, Indiana	Westinghouse
18	400①	500/1000	600	d-c	Geared	60 in. Temper mill	Carnegie-Illinois Steel Corporation	Gary, Indiana	Westinghouse
19	400	250/600	250	d-c	Direct	Hot strip mill	Sharon Steel Corporation	Sharon, Pennsylvania	General Electric
20	400	300/900	600	d-c	Geared	Rod and skelp mill	Acindar Industria Argentina de Aceros, S. A.	Argentina	General Electric
21	400	300/900	600	d-c	Geared	Rod and skelp mill	Acindar Industria Argentina de Aceros, S. A.	Argentina	General Electric
22	400	300/900	600	d-c	Geared	14 in. Continuous rod and merchant mill	Acero Del Pacifico	Chile	General Electric
23	400	600/1200	250	d-c	Direct	Sendzimir mill	Republic Steel Corporation	Massillon, Ohio	General Electric
24	400	225/675	600	d-c	Geared	Rod mill	Colorado Fuel and Iron Corporation	Pueblo, Colorado	General Electric
25	400	225/675	600	d-c	Geared	Rod mill	Colorado Fuel and Iron Corporation	Pueblo, Colorado	General Electric
26	400	225/675	600	d-c	Geared	Rod mill	Colorado Fuel and Iron Corporation	Pueblo, Colorado	General Electric
27	400	400/800	250	d-c	Geared	42 in. Skin pass tension rolls	Youngstown Sheet and Tube Company	Indiana Harbor, Indiana	Westinghouse
28	400	600/750	350	d-c	Direct	Skin pass mill	Bethlehem Steel Company	Sparrows Point, Maryland	Westinghouse
29	400	250/1000	600	d-c	Geared	2-High temper pass mill	Tennessee Coal, Iron and Railroad Company	Fairfield, Alabama	Allis-Chalmers
30	450②	300/1100	600	d-c	Geared	48 in. Skin pass reel	Du Nord Et De L'Est	France	Westinghouse
31	500	200/800	600	d-c	Direct	Vertical edger	A. R. B. E. D.	Luxembourg	General Electric
32	500	250/750	600	d-c	Direct	Reel motor	Altos Hornos de Mexico, S. A.	Mexico	General Electric
33	500	250/750	600	d-c	Direct	Reel motor	Altos Hornos de Mexico, S. A.	Mexico	General Electric
34	500	750	400	50†	Direct	Sheet bar mill	Acero Del Pacifico	Chile	General Electric
35	500	125/406	700	d-c	Geared	Hot strip roughing edger	South African Iron and Steel Industrial Corporation, Limited	South Africa	Westinghouse
36	500	300/500	600	d-c	Direct	56 in. Skin pass mill	South African Iron and Steel Industrial Corporation, Limited	South Africa	Westinghouse
37	500	300/500	600	d-c	Direct	56 in. Skin pass tension rolls	South African Iron and Steel Industrial Corporation, Limited	South Africa	Westinghouse
38	500②	250/965	600	d-c	Geared	72 in. Sheet temper mill	Carnegie-Illinois Steel Corporation	McKeesport, Pennsylvania	Allis-Chalmers
39	600②	225/900	600	d-c	Direct	Skin pass mill reel	United Engineering and Foundry Company	Czechoslovakia	General Electric
40	600②	225/900	600	d-c	Direct	Skin pass mill reel	United Engineering and Foundry Company	Czechoslovakia	General Electric
41	600	240	2300	60†	Geared	Sheet mill	Cia Acesita	Brazil	General Electric
42	600	240	2300	60†	Geared	Sheet mill	Cia Acesita	Brazil	General Electric
43	600	300/900	600	d-c	Geared	Rod and skelp mill	Acindar Industria Argentina de Aceros, S. A.	Argentina	General Electric
44	600	300/900	600	d-c	Geared	Rod and skelp mill	Acindar Industria Argentina de Aceros, S. A.	Argentina	General Electric
45	600	200/600	600	d-c	Direct	Rod and skelp mill	Acindar Industria Argentina de Aceros, S. A.	Argentina	General Electric
46	600	200/600	600	d-c	Direct	Rod and skelp mill	Acindar Industria Argentina de Aceros, S. A.	Argentina	General Electric
47	600	300/900	600	d-c	Geared	10 in. mill	Acero Del Pacifico	Chile	General Electric
48	600	200/700	750	d-c	Direct	56 in. Tandem cold strip reel	South African Iron and Steel Industrial Corporation, Limited	South Africa	Westinghouse
49	600	200/700	600	d-c	Geared	54 in. Reversing cold strip reel	Crucible Steel Company of America	Midland, Pennsylvania	Westinghouse
50	600	200/700	600	d-c	Geared	54 in. Reversing cold strip reel	Crucible Steel Company of America	Midland, Pennsylvania	Westinghouse
51	600	200/700	600	d-c	Geared	54 in. Tandem cold strip reel	Crucible Steel Company of America	Midland, Pennsylvania	Westinghouse
52	600②	300/1100	700	d-c	Geared	66 in. Tandem cold strip reel	Du Nord Et De L'Est	France	Westinghouse
53	600	225/900	600	d-c	Geared	4-High temper mill	Tennessee Coal, Iron and Railroad Company	Fairfield, Alabama	Allis-Chalmers
54	600	400/1000	600	d-c	Geared	72 in. Sheet temper mill	Carnegie-Illinois Steel Corporation	McKeesport, Pennsylvania	Allis-Chalmers
55	700②	300/1200	600	d-c	Geared	60 in. Temper reel	Carnegie-Illinois Steel Corporation	Gary, Indiana	Westinghouse
56	800	400/1000	600	d-c	Geared	Reversing cold strip mill	Signode Steel Strapping Company	Sparrows Point, Maryland	General Electric
57	800②	300/1160	600	d-c	Geared	Reversing cold mill reel	A. R. B. E. D.	Luxembourg	General Electric
58	800②	300/1160	600	d-c	Geared	Reversing cold mill reel	A. R. B. E. D.	Luxembourg	General Electric
59	800②	300/1160	600	d-c	Geared	Reversing cold mill reel	A. R. B. E. D.	Luxembourg	General Electric
60	800②	300/1160	600	d-c	Geared	Reversing cold mill reel	A. R. B. E. D.	Luxembourg	General Electric
61	800	250/625	600	d-c	Geared	Rod mill	Colorado Fuel and Iron Corporation	Pueblo, Colorado	General Electric
62	800	370	5600	50†	Geared	66 in. Hot strip scale breaker	Denain Et D'Anzin	France	Westinghouse
63	800	200/400	600	d-c	Direct	84 in. Temper mill	Carnegie-Illinois Steel Corporation	Gary, Indiana	Westinghouse
64	800②	200/800	600	d-c	Geared	84 in. Temper reel	Carnegie-Illinois Steel Corporation	Gary, Indiana	Westinghouse
65	800	300/600	600	d-c	Geared	66 in. Skin pass mill	Du Nord Et De L'Est	France	Westinghouse
66	800	720	2300	60cy	Geared	19 in. Piercing mill	American Brass Company	Waterbury, Connecticut	Allis-Chalmers
67	900	225/675	600	d-c	Geared	14 in. Continuous rod and merchant mill	Acero Del Pacifico	Chile	General Electric
68	900	225/675	600	d-c	Geared	14 in. Continuous rod and merchant mill	Acero Del Pacifico	Chile	General Electric
69	1000②	150/600	750	d-c	Direct	4-Stand cold strip mill	United Engineering and Foundry Company	Czechoslovakia	General Electric
70	1000	6600/3300	750	50†	Geared	Rolling mill	Indian Steel and Wire Products	Tatanagar, India	General Electric
71	1000	500	4000	50†	Geared	18 in. Rod and merchant mill	Acero Del Pacifico	Chile	General Electric
72	1000	225/675	600	d-c	Geared	12 in. Rod and merchant mill	Acero Del Pacifico	Chile	General Electric
73	1000	350/835	600	d-c	Geared	Rod and skelp mill	Acindar Industria Argentina de Aceros, S. A.	Argentina	General Electric
74	1000	350/835	600	d-c	Geared	Rod and skelp mill	Acindar Industria Argentina de Aceros, S. A.	Argentina	General Electric
75	1000	600	4160	60*	Geared	Brass rolling mill	Stamford Rolling Mills Company	Springdale, Connecticut	General Electric
76	1000	900	6600	60*	Geared	Rod mill	American Steel and Wire Company	Joliet, Illinois	General Electric
77	1000	900	6600	60*	Geared	Rod mill	American Steel and Wire Company	Joliet, Illinois	General Electric
78	1000	400/900	600	d-c	Geared	Rod mill	Colorado Fuel and Iron Corporation	Pueblo, Colorado	General Electric
79	1000	200/600	600	d-c	Geared	Merchant mill	Kaiser Company, Iron and Steel Division	Fontana, California	Westinghouse
80	1000	720	4600	60	Geared	16-33-34 in. 4-High mill	Revere Copper and Brass Company	Detroit, Michigan	Allis-Chalmers

ELECTRIC MOTORS OVER THREE HUNDRED HORSEPOWER

(CONTINUED)

Item	Horse-power	Revolutions per minute	Volts	Frequency	Method of drive	Kind of mill	Purchaser	Location	Manufacturer
81	1125	300/600	600	d-c	Direct	4-High temper pass mill	Tennessee Coal, Iron and Railroad Company	Fairfield, Alabama	Allis-Chalmers
82	1250	275/550	600	d-c	Geared	Skin pass mill	United Engineering and Foundry Company	Czechoslovakia	General Electric
83	1250	275/550	600	d-c	Geared	Skin pass mill	United Engineering and Foundry Company	Czechoslovakia	General Electric
84	1250	300	4000	50†	Geared	Sheet mill	Acero Del Pacifico	Chile	General Electric
85	1250	600/960	600	d-c	Geared	24 in. Reversing cold strip mill	Detroit Steel Corporation	New Haven, Connecticut	General Electric
86	1250	450/690	600	d-c	Geared	Rod and skelp mill	Acindar Industria Argentina de Aceros, S. A.	Argentina	General Electric
87	1250	200/500	600	d-c	Geared	Rod mill	Colorado Fuel and Iron Corporation	Argentina Pueblo, Colorado	General Electric General Electric
88	1250	400/800	600	d-c	Geared	Aluminum cold strip mill	Aluminum Company of America	Edgewater, New Jersey	Westinghouse
89	1250	400/1000	600	d-c	Geared	Single stand brass rundown mill	Scoville Manufacturing Company	Waterbury, Connecticut	Westinghouse
90	1250	400/1000	600	d-c	Geared	Single stand brass finishing mill	Scoville Manufacturing Company	Waterbury, Connecticut	Westinghouse
91	1500	750	4000	50*	Geared	10 in. Rod mill	Acero Del Pacifico	Chile	General Electric
92	1500	150/300	600	d-c	Geared	44 in. Reversing cold strip mill	Altos Hornos de Mexico, S. A.	Mexico	General Electric
93	1500	250/650	600	d-c	Geared	54 in. Tandem cold strip mill	Crucible Steel Company of America	Midland, Pennsylvania	Westinghouse
94	1500	250/650	600	d-c	Geared	54 in. Tandem cold strip mill	Crucible Steel Company of America	Midland, Pennsylvania	Westinghouse
95	1500	250/650	600	d-c	Geared	54 in. Tandem cold strip mill	Crucible Steel Company of America	Midland, Pennsylvania	Westinghouse
96	1500	300/600	600	d-c	Geared	48 in. Skin pass mill	Du Nord Et De L'Est	France	Westinghouse
97	1500	300/720	750	d-c	Geared	56 in. Tandem cold strip mill	South African Iron and Steel Industrial Corporation, Limited	South Africa	Westinghouse
98	1500	400/800	600	d-c	Geared	Aluminum cold strip mill	Aluminum Company of Canada	Brazil	Westinghouse
99	2000	500/900	600	d-c	Geared	Cold strip mill	Tennessee Coal, Iron and Railroad Company	Birmingham, Alabama	General Electric
100	2000	360/720	2300	60†	Geared	Brass breakdown mill	Scoville Manufacturing Company	Ansonia, Connecticut	General Electric
101	2000	500/750	600	d-c	Geared	Rod mill	Colorado Fuel and Iron Corporation	Pueblo, Colorado	General Electric
102	2000	40/80	600	d-c	Direct	Reversing hot aluminum mill	Aluminum Company of Canada	Brazil	Westinghouse
103	2000	80/160	700	d-c	Direct	Reversing hot strip mill	Companhia Siderurgica Belgo	Brazil	Westinghouse
104	2000	200/500	600	d-c	Geared	54 in. Reversing cold strip mill	Crucible Steel Company of America	Midland, Pennsylvania	Westinghouse
105	2500	90/270	750	d-c	Direct	4-Stand cold strip mill	United Engineering and Foundry Company	Czechoslovakia	General Electric
106	2500	500	4000	50*	Geared	Billet mill	Acero Del Pacifico	Chile	General Electric
107	2500	300/600	600	d-c	Geared	Reversing cold strip mill	A. R. B. E. D.	Luxembourg	General Electric
108	2500	300/600	600	d-c	Geared	Reversing cold strip mill	A. R. B. E. D.	Luxembourg	General Electric
109	2500	60/140	700	d-c	Direct	66 in. Tandem cold strip mill	Du Nord Et De L'Est	France	Westinghouse
110	2500	75/150	600	d-c	Direct	Reversing hot strip mill	A. M. Byers Company	Ambridge, Pennsylvania	Westinghouse
111	2500	90/180	700	d-c	Direct	66 in. Tandem cold strip mill	Du Nord Et De L'Est	France	Westinghouse
112	2500	150/300	750	d-c	Direct	56 in. Tandem cold strip mill	South African Iron and Steel Industrial Corporation, Limited	South Africa	Westinghouse
113	2500②	110/220	700	d-c	Direct	66 in. Tandem cold strip mill	Du Nord Et De L'Est	France	Westinghouse
114	2500	225/450	750	d-c	Direct	56 in. Tandem cold strip mill	South African Iron and Steel Industrial Corporation, Limited	South Africa	Westinghouse
115	3000	175/350	700	d-c	Direct	56 in. Hot strip finishing mill	South African Iron and Steel Industrial Corporation, Limited	South Africa	Westinghouse
116	3000②	300/570	750	d-c	Direct	56 in. Tandem cold strip mill	South African Iron and Steel Industrial Corporation, Limited	South Africa	Westinghouse
117	3000	495	5600	50†	Geared	66 in. Hot strip roughing mill	Denain Et D'Anzin	France	Westinghouse
118	3500①	40/80	750	d-c	Direct	Slabbing mill	A. R. B. E. D.	Luxembourg	General Electric
119	3500①	40/80	750	d-c	Direct	Slabbing mill	A. R. B. E. D.	Luxembourg	General Electric
120	3500	50/120	675	d-c	Direct	32 in. Blooming mill	Acero Del Pacifico	Chile	General Electric
121	3500	150/340	700	d-c	Geared	66 in. Hot strip finishing mill	Denain Et D'Anzin	France	Westinghouse
122	3500	150/340	700	d-c	Direct	66 in. Hot strip finishing mill	Denain Et D'Anzin	France	Westinghouse
123	3500①	40/80	700	d-c	Direct	Reversing blooming mill	Denain Et D'Anzin	France	Westinghouse
124	3500	40/80	700	d-c	Direct	Reversing blooming mill	Denain Et D'Anzin	France	Westinghouse
125	3500	175/350	700	d-c	Geared	56 in. Hot strip finishing mill	South African Iron and Steel Industrial Corporation, Limited	South Africa	Westinghouse
126	3500	175/350	700	d-c	Geared	56 in. Hot strip finishing mill	South African Iron and Steel Industrial Corporation, Limited	South Africa	Westinghouse
127	3500	175/350	700	d-c	Geared	56 in. Hot strip finishing mill	South African Iron and Steel Industrial Corporation, Limited	South Africa	Westinghouse
128	3500	175/350	700	d-c	Geared	56 in. Hot strip finishing mill	South African Iron and Steel Industrial Corporation, Limited	South Africa	Westinghouse
129	3500	150/300	700	d-c	Direct	56 in. Hot strip finishing mill	United Engineering and Foundry Company	Czechoslovakia	General Electric
130	4000①	125/360	750	d-c	Direct	4-Stand cold strip mill	United Engineering and Foundry Company	Czechoslovakia	General Electric
131	4000①	200/500	750	d-c	Direct	4-Stand cold strip mill	United Engineering and Foundry Company	Czechoslovakia	General Electric
132	4000①	250/580	750	d-c	Direct	4-Stand cold strip mill	Newport Rolling Mill Company	Newport, Kentucky	Westinghouse
133	4000	100/200	700	d-c	Direct	Reversing hot strip mill	Denain Et D'Anzin	France	Westinghouse
134	4000	100/220	700	d-c	Direct	66 in. Hot strip finishing mill	Denain Et D'Anzin	France	Westinghouse
135	4000	135/270	700	d-c	Direct	66 in. Hot strip finishing mill	Denain Et D'Anzin	France	Westinghouse
136	4000	145/290	700	d-c	Geared	66 in. Hot strip finishing mill	Denain Et D'Anzin	France	Westinghouse
137	4000	145/326	700	d-c	Geared	66 in. Hot strip finishing mill	Denain Et D'Anzin	France	Westinghouse
138	4000*	500	5600	50	Geared	66 in. Hot strip roughing mill	Denain Et D'Anzin	France	Westinghouse
139	4000*	500	5600	50	Geared	66 in. Hot strip roughing mill	Denain Et D'Anzin	France	Westinghouse
140	4000*	500	5600	50	Geared	66 in. Hot strip roughing mill	Denain Et D'Anzin	France	Westinghouse
141	5000	40/80	800	d-c	Geared	42 x 66 in. 2-High reversing rougher	A. R. B. E. D.	Luxembourg	General Electric
142	5000	70/120	800	d-c	Geared	66 in. 4-High reversing hot strip mill	A. R. B. E. D.	Luxembourg	General Electric
143	6000	40/100	600	d-c	Direct	Blooming mill	Allegheny Ludlum Steel Corporation	Brackenridge Pennsylvania	General Electric
144	6000	50/120	700	d-c	Direct	Reversing blooming mill	Wheeling Steel Corporation	Steubenville, Ohio	Westinghouse
145	7000	40/100	700	d-c	Direct	Reversing blooming mill	Polish-American Supply Commission	Poland	Westinghouse

*Synchronous †Wound rotor motor ①Twin motor drive ②Double armature

RECAPITULATION

Company	Location	Type of mill	Number of motors	Total horsepower
A. R. B. E. D.	Luxembourg	28 x 66 in. Skin pass mill	4	1200
		Reversing cold strip mill	6	8200
		Slabbing mill	3	7500
		42 x 66 in. 2-High reversing rougher	1	5000
		66 in. 4-High reversing hot strip mill	1	5000
Acero Del Pacifico	Chile	Sheet mill	2	1550
		14 in. Continuous rod and merchant mill	3	2200
		Sheet bar mill	1	500
		18 in. Rod and merchant mill	1	1000
		12 in. Rod and merchant mill	1	1000
		10 in. Rod mill	2	2100
		Billet mill	1	2500
		32 in. Blooming mill	1	3500
Acindar Industria Argentia de Aceros, S. A.	Argentina	Rod and skelp mill	11	7150
Allegheny Ludlum Steel Corporation	Brackenridge, Pennsylvania	Blooming mill	1	6000
Altos Hornos de Mexico, S. A.	Mexico	44 in. Reversing cold strip mill	3	2500
Aluminum Company of America	Edgewater, New Jersey	Aluminum cold strip mill	1	1250
Aluminum Company of Canada	Brazil	Aluminum cold strip mill	1	1500
		Reversing hot strip mill	1	2000
American Brass Company	Waterbury, Connecticut	19 in. Piercing mill	1	800
American Steel and Wire Company	Joliet, Illinois	Rod mill	2	2000
Bethlehem Steel Company	Sparrows Point, Maryland	Skin pass mill	1	400
A. M. Byers Company	Ambridge, Pennsylvania	Reversing hot strip mill	1	2500
Carnegie-Illinois Steel Corporation	Gary, Indiana	60 in. Temper mill	6	2600
		84 in. Temper mill	3	2000
	McKeesport, Pennsylvania	72 in. Sheet temper mill	2	1100
Cia Acesita	Brazil	Sheet mill	2	1200
Colorado Fuel and Iron Corporation	Pueblo, Colorado	Rod mill	10	7150
Companhia Siderurgica Belgo	Brazil	Reversing hot strip mill	1	2000
Crucible Steel Company of America	Midland, Pennsylvania	54 in. Tandem cold strip mill	4	5100
		54 in. Reversing cold strip mill	3	3200
Denan Et D'Anzin	France	66 in. Hot strip scale breaker	1	800
		66 in. Hot strip roughing mill	4	15,000
		66 in. Hot strip finishing mill	6	23,000
		Reversing blooming mill	2	7000
Detroit Steel Corporation	New Haven, Connecticut	24 in. Reversing cold strip mill	1	1250
Du Nord Et De L'Est	France	66 in. Skin pass mill	1	800
		48 in. Skin pass mill	2	1950
		66 in. Tandem cold strip mill	4	8100
Indian Steel and Wire Products	Tatanagar, India	Rolling mill	1	1000
Kaiser Company, Iron and Steel Division	Fontana, California	Merchant mill	1	1000
Lukens Steel Company	Coatesville, Pennsylvania	Flanging mill	1	350
Newport Rolling Mill Company	Newport, Kentucky	Reversing hot strip mill	1	4000
Polish-American Supply Commission	Poland	Reversing blooming mill	1	7000
Republic Steel Corporation	Massillon, Ohio	Sendzimir mill	1	400
Revere Copper and Brass Company	Detroit, Michigan	16-33-34 in. 4-High mill	1	1000
Scoville Manufacturing Company	Waterbury, Connecticut	Single stand brass rundown mill	1	1250
		Single stand brass finishing mill	1	1250
	Ansonia, Connecticut	Brass breakdown mill	1	2000
Sharon Steel Corporation	Sharon, Pennsylvania	Hot strip mill	1	400
Signode Steel Strapping Company	Sparrows Point, Maryland	Cold strip mill	1	800
South African Iron and Steel Industrial Corporation, Limited	South Africa	Hot strip roughing edger	1	500
		56 in. Skin pass mill	3	1300
		56 in. Tandem cold strip mill	5	10,100
		56 in. Hot strip finishing mill	6	20,500
Stamford Rolling Mills Company	Springdale, Connecticut	Brass rolling mill	1	1000
Tennessee Coal, Iron and Railroad Company	Fairfield, Alabama	4-High temper pass mill	3	2125
	Birmingham, Alabama	Cold strip mill	1	2000
United Engineering and Foundry Company	Czechoslovakia	4-Stand cold strip mill	5	15,500
		Skin pass mill	4	2700
Wheeling Steel Corporation	Steubenville, Ohio	Reversing blooming mill	1	6000
Youngstown Sheet and Tube Company	Indiana Harbor, Indiana	42 in. Skin pass tension roll	1	400

Type of motors purchased	Number of motors	Total horsepower
Alternating current motors	20	31,850
Direct current motors	125	201,925
Total	145	233,175

A. J. Fisher

PRESIDENT, 1948

ASSOCIATION OF IRON AND STEEL ENGINEERS

A. J. FISHER was graduated from the Colorado State preparatory school and later from the University of Colorado, college of engineering, with a degree in mechanical engineering. Mr. Fisher began his steel mill employment with the Bethlehem Steel Company at the Sparrows Point, Maryland, plant as assistant master mechanic of the sheet and tin mill division in 1924. After serving in several capacities in various departments, Mr. Fisher became fuel engineer in 1929, and held that position until December, 1947 when he became assistant chief engineer of construction at Bethlehem, Pennsylvania.

The President's Message

The operating and technical problems of the iron and steel industry are becoming more complex every day. Most of us now realize that there is much still to be learned about the steel business. Besides our knowledge of and participation in the operation of the industry, we must at the same time be capable of passing this knowledge on to others, in order that they can do as well as we have done, if not better. With one hand we have to be instructors, and with the other, engineers and operators. As we strive to advance, we must look back and give the other fellow a hand.

It has always been the policy of the Association of Iron and Steel Engineers to foster the exchange of technical information between engineers and operators; between the old and young; between the advanced and the less advanced. To further this policy, the officers and directors of the Association will spend much time and effort in developing ways and means of better serving the Association membership. Special attention will be given to our younger members. We want to help them to get all the available basic technical information they need about our industry and their specific jobs. We want them to get a firm foundation and a good start. We want them to become better foremen, better engineers, and better operators.

A. J. FISHER,

President.

C. H. WILLIAMS
First Vice President

A. S. GLOSSBRENNER
Second Vice President

J. F. BLACK
Treasurer

NEWLY ELECTED OFFICERS AND DIRECTORS

ASSOCIATION OF IRON AND STEEL ENGINEERS -- 1948

C. H. WILLIAMS was graduated from the University of Colorado in 1926 and was employed by Jones and Laughlin Steel Corporation as shear foreman in their Pittsburgh plant. In 1927 he became a junior engineer in the power department of National Tube Company at Pittsburgh, shifting in 1930 to the Ohio Works of Carnegie Steel Company. Here he served successively as junior engineer, power and fuel engineer, and assistant chief engineer. In 1940 Mr. Williams was transferred to the Pittsburgh office of Carnegie-Illinois Steel Corporation as power and fuel engineer on the staff of the chief engineer, and was subsequently appointed assistant chief engineer of the Pittsburgh district. In 1941 he was placed in charge of a newly organized defense engineering staff to coordinate the engineering of defense steel plant expansions of the company in the Pittsburgh district. He was subsequently transferred to the United States Steel Corporation of Delaware as assistant to the vice president of engineering, and in 1943 to chief engineer of the Pittsburgh district, Carnegie-Illinois Steel Corporation. He was appointed chief engineer of Carnegie-Illinois Steel Corporation in January, 1948.

ALBERT S. GLOSSBRENNER attended the University of Wisconsin and later entered the employ of the old Illinois Steel Company, one of the predecessors of Carnegie-Illinois Steel Corporation, at the Gary, Indiana tin plate plant. He then transferred to the same company's South works at Chicago as assistant foreman. Five years later he joined Youngstown Sheet and Tube Company at Youngstown, Ohio, as assistant superintendent of the hot strip mill, becoming superintendent about three years later. He was appointed superintendent of the Brier Hill plant in September, 1942, and in 1943 was named general superintendent of the Youngstown district of Youngstown Sheet and Tube Company. In December, 1946, Mr. Glossbrenner was named assistant vice president of operations.

JOHN F. BLACK received his elementary schooling in the Enid, Oklahoma, city schools, and attended the United States Naval Academy, class of 1926. He started in the steel business as pipefitter helper at Bethlehem Steel Company's Sparrow Point plant, progressing to steel shipper, labor foreman, gashouse foreman, general foreman of gas producers, combustion engineer, and general foreman of pipe mills. In 1941 he transferred to Atlas Steels Limited, Welland, Ontario, as fuel engineer and in 1943 was made assistant works manager. In January, 1947, Mr. Black was appointed general superintendent, Buffalo plant, Wickwire Spencer Steel division of the Colorado Fuel and Iron Corporation.

I. N. TULL was born in Anniston, Alabama, reared in North Carolina, and graduated from North Carolina State College in electrical engineering in 1910. After a brief period of telephone work, he entered General Electric Company's test course at Schenectady. He was transferred to their Cleveland office's engineering department in 1912, remaining there until 1915, when he was employed by Corrigan, McKinney and Company as electrical engineer. The next 12 years were spent in engineering and construction work as that company built blast furnaces and a steel plant at Cleveland, Ohio and proceeded with extensive electrification of their iron mines and the opening of coal mines. In 1927, general supervision of electrical maintenance and operations was added to the construction duties. After the merger with Republic Steel Corporation in 1935, Mr. Tull became electrical superintendent of the Cleveland district for Republic.

JOHN L. YOUNG is a native of Evansville, Indiana and graduated from the University of Indiana. Mr. Young began his career with the Timken Roller Bearing Company in Canton, Ohio, where he held various positions in the alloy tube and steel departments; he later transferred to the metallurgical department. In 1930, Mr. Young went to Pittsburgh for Timken as a development engineer, and later returned to Canton and became assistant general manager of Timken's industrial division. Mr. Young joined the United Engineering and Foundry Company, Pittsburgh, Pennsylvania in 1936. In 1941, he was loaned as project manager to design and construct the Defense Plant Corporation's aluminum rolling mills at Trentwood, Washington. He was vice president in charge of industrial research and development of United Engineering and Foundry Company, before assuming his present position as vice president in charge of engineering of United States Steel Corporation's National Tube Company in 1945.

WALTER NIELSEN was born in Wisconsin, and graduated from University of Michigan in 1932. He was employed by Sloss Sheffield Steel and Iron Company, Birmingham, Alabama from 1933 to 1937 as burden clerk, stockhouse foreman and yardmaster. He then went to Woodward Iron Company as utility engineer. He next spent three years as a management engineer in Birmingham for Neville, Brown & Walters, doing cost reduction and consulting work. In 1940, he returned to Sloss Company as practice man, and was made superintendent of North Birmingham furnace plant in 1941.

I. N. TULL
Secretary

JOHN L. YOUNG
Director

WALTER NIELSEN
Director

R. W. GRAHAM
Director

W. J. TUNNY
Director

E. C. McDONALD
Director

R. W. GRAHAM has been employed in the steel industry since 1916, except for 18 months spent in naval service in World War I, as radio and communication officer on U.S.S. Arizona. Starting with Lackawanna Steel Company as assistant electrical engineer, he remained in that capacity until the Lackawanna plant was absorbed by Bethlehem Steel Company in 1923. He then worked as assistant superintendent of the electrical department until April, 1943, when he was made electrical superintendent. He is a graduate of North Dakota and Cornell Universities and taught in Cornell Engineering College for three years.

WILLIAM J. TUNNY was born in Chicago, Illinois where he received his grammar and high school education. He obtained his electrical engineering training at Armour Institute of Technology in Chicago, now known as Illinois Institute of Technology. He then joined the engineering department of the Youngstown Sheet and Tube Company, East Chicago, Indiana, where he subsequently progressed as electrical testing engineer, chief of the electrical testing department, and in 1943 was promoted to his present position of assistant electrical engineer.

E. C. McDONALD received his elementary schooling in Duquesne, Pennsylvania and graduated from the University of Pittsburgh in 1922 with a degree in metallurgical engineering. His first position after graduation was with Carnegie Steel Company in Duquesne as a test engineer in the fuel and experimental department. In 1926 he accepted the position of assistant combustion engineer of Donner Steel Company in Buffalo, New York. Donner Steel was combined with Republic Steel Corporation in 1930 and shortly thereafter Mr. McDonald was made Buffalo district combustion engineer. When Corrigan-McKinney Steel Corporation was merged with Republic in 1935, he was transferred to Cleveland as district combustion engineer, holding that position at the present time.

J. ARTHUR SHIMMIN was born in Monmouth, Illinois, where he received his early education and also attended Monmouth College. After three years with the Delco Light Company in Illinois, he worked as electrician for the Continental Motors in Muskegon, Michigan. In 1923, he entered the service of the Detroit Edison Company, where he remained in various capacities until 1942. During this period Mr. Shimmin attended Wayne University, from whence he received a bachelor of science degree in 1939. He joined the Rotary Electric Steel Company in 1942 as superintendent of maintenance, and is now plant engineer in charge of engineering, mechanical and electrical maintenance, and construction.

C. R. HAND, assistant superintendent of the mechanical department at Bethlehem Steel Company, Sparrows Point, Maryland, was born at Baltimore, Maryland, and attended public schools, high schools and night schools in Baltimore and Sparrows Point. He began work in the steel plant at Sparrows Point in 1911 as an open hearth helper and worked in various departments including ore mines, coke ovens, blast furnaces, shipyard, metallurgical and mechanical departments. He was made lubrication engineer in 1928, and was appointed to his present position in 1946.

E. L. ANDERSON has been associated with the iron and steel industry for the past 29 years, having started in the electrical department of the Bethlehem Steel Company at Sparrows Point, Maryland, in 1917. He was transferred to the Johnstown plant of Bethlehem in 1937, and was appointed superintendent of the electrical department of that plant in 1940.

J. A. SHIMMIN
Director

C. R. HAND
Director

E. L. ANDERSON
Director

M. B. ANTRIM
Director

R. E. BOBBITT, JR.
Director

C. W. BRUCE
Director

MALCOLM B. ANTRIM was born at West Pittston, Pennsylvania, in 1916 and was graduated from Rensselaer Polytechnic Institute in 1938 with a bachelor of science degree in electrical engineering. After being employed a short time by the firm of Repp and Menzies, engineers of Scranton, Pennsylvania, who were engaged in the design of coal cleaning and sizing plants, he was appointed to the graduate student training course of the Westinghouse Electric Corporation, East Pittsburgh, Pennsylvania. Upon the completion of this course he was transferred to the Philadelphia district office of Westinghouse and assigned to the steel mill section of the industrial sales department. He was employed in 1941 by the Lukens Steel Company as technical assistant to the electrical superintendent advancing later to his present position as electrical engineer.

R. E. BOBBITT, JR. was graduated in electrical engineering from Georgia School of Technology in 1918. He then entered the engineering department of Magnolia Petroleum Company, Beaumont, Texas, and soon moved to the engineering department of Atlantic Steel Company, Atlanta, Georgia. In 1920 he joined the Armour Fertilizer Works in Atlanta, returning to Atlantic Steel in 1922. Transferred to the mechanical department in 1923, he was made general master mechanic in 1939, in charge of mechanical, electrical and steam engineering departments, and in 1945 was advanced to chief engineer.

C. W. BRUCE was graduated from Case Institute of Technology in mechanical engineering in 1933. He started in the steel business in the blooming mill at the Corrigan-McKinney Steel Company, and in 1934 transferred to the combustion department. After the merger with Republic Steel Corporation in 1935 he continued in the combustion department until 1942 at which time he was transferred to the Chicago district of Republic Steel Corporation as combustion engineer. In 1947 he was made assistant chief engineer of the Chicago district.

J. H. VOHR was graduated from Cornell University in mechanical and electrical engineering in 1916 and became associated with the New York State Railways as an electrical engineer. After serving in World War I, he joined the American Sheet and Tin Plate Company at Farrell, Pennsylvania, and later was transferred as assistant superintendent of strip mills to the company's plant at Gary. After leaving the company in 1931, he was engaged with the installation and operation of the wide strip mills of the Inland Steel Company and Youngstown Sheet and Tube Company. In 1936 he joined the Granite City Steel Company, Granite City, Illinois, as superintendent of the hot and cold strip mills and was promoted in 1937 to general superintendent of plants. In 1942 he transferred to the Carnegie-Illinois Steel Corporation, being stationed at the general offices in Pittsburgh until his appointment in in 1943 as assistant general superintendent of South works at Chicago, Illinois.

D. N. EVANS, assistant general master mechanic, Inland Steel Company, East Chicago, Indiana, is a native of Wisconsin and attended Marquette University, Clemson College, University of Wisconsin. He received a degree in the mechanical engineering from the University of Oklahoma in 1935. Since that time he was employed by the Inland Steel Company in the following positions: maintenance department of 40 in. blooming mill, machine shop foreman, mechanical turn foreman, hot strip mill, lubrication engineer, and at present assistant general master mechanic.

A. G. ERICSON was graduated from School of Mines, Filipstad, Sweden in 1916. He arrived in the United States in 1920, and started work with the Carnegie Steel Company at Homestead steel works in 1924 and successively progressed as mechanical draftsman, engineer, assistant to the chief engineer, assistant chief engineer, and in 1938 was appointed chief engineer for the Homestead district works of Carnegie-Illinois Steel Corporation.

J. H. VOHR
Director

D. N. EVANS
Director

A. G. ERICSON
Director

National Committees for 1948

ASSOCIATION OF IRON AND STEEL ENGINEERS

General Chairman, A. J. Fisher

ADVISORY COMMITTEE

Past Presidents, AISE

1907-1908 JAMES FARRINGTON, *Electrical Superintendent*, Wheeling Steel Corporation, Steubenville, Ohio.
1909 JOHN C. REED (Retired), Steelton, Pennsylvania.
1910 F. P. TOWNSEND, *Development Engineer*, Copperweld Steel Company, Glassport, Pennsylvania.
1914 E. FRIEDLANDER (Retired), Los Angeles, California.
1919 D. M. PETTY, *President*, Philadelphia, Bethlehem and New England Railroad Company, Bethlehem, Pennsylvania.
1921 E. S. JEFFRIES, *President and General Manager*, Universal Boring Machine Company, Hudson, Massachusetts.
1922 W. S. HALL, United Engineers and Constructors, 111 West Washington Street, Chicago, Illinois.
1923 R. B. GERHARDT (Retired), Bethlehem, Pennsylvania.
1924 R. S. SHOEMAKER, Brooks Oil Company, Middletown, Ohio.
1926 G. H. SCHAEFFER, *Electrical Engineer*, Carpenter Steel Company, Reading, Pennsylvania.
1930 F. W. CRAMER, *Electrical Engineer*, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania.
1931 F. O. SCHNURE, *Electrical Superintendent*, Bethlehem Steel Company, Sparrows Point, Maryland.
1932 J. J. BOOTH, *Superintendent of Maintenance*, Carnegie-Illinois Steel Corporation, Duquesne, Pennsylvania.
1933 J. D. DONOVAN (Retired), Massillon, Ohio
1935 *Chairman:* W. H. BURR, *Electrical Superintendent*, Lukens Steel Company, Coatesville, Pennsylvania.
1937 H. G. R. BENNETT, 160 Academy Avenue, Pittsburgh, Pennsylvania.
1938 L. F. COFFIN, *Superintendent*, Mechanical Department, Bethlehem Steel Company, Sparrows Point, Maryland.
1939 C. CLARKE WALES, *Engineering Department*, National Tube Company, Pittsburgh, Pennsylvania.
1940 J. A. CLAUSS, *Vice President in Charge of Engineering*, Great Lakes Steel Corporation, Ecorse, Detroit, Michigan.
1941 W. A. PERRY, *Assistant to General Superintendent*, Inland Steel Company, East Chicago, Indiana.
1943 F. E. FLYNN, *District Manager*, Republic Steel Corporation, Warren, Ohio.
1944 CHARLES L. McGRANAHAN, *Assistant General Superintendent*, Jones and Laughlin Steel Corporation, Pittsburgh Works, Pittsburgh, Pennsylvania.
1945 J. L. MILLER, *Assistant Chief Combustion Engineer*, Republic Steel Corporation, Cleveland, Ohio.
1946 FREEMAN H. DYKE, *Assistant General Manager*, Wheeling Steel Corporation, Steubenville, Ohio.
1947 L. R. MILBURN, *Consulting Engineer*, Detroit, Michigan.

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R. E. BOBBITT JR., *Chief Engineer*, Atlantic Steel Company, Atlanta, Georgia.
C. W. BRUCE, *Assistant Chief Engineer*, Republic Steel Corporation, Chicago, Illinois.
LEO L. WARREN, *Chief Electrician*, Birmingham Slag Company, Birmingham, Alabama.
R. L. HALL, *Superintendent*, Mechanical and Electrical Department Tennessee Coal, Iron and Railroad Company, Ensley Works, Ensley, Alabama.
JAMES O. DAGUE, *General Foreman*, Mechanical Department Bethlehem Steel Company, Lackawanna, New York.
D. W. McLEAN, *Assistant General Master Mechanic*, Steel Company of Canada, Ltd., Hamilton, Ontario, Canada.
RYLAND J. BEESWY, *Assistant Superintendent, Electrical and Power Department*, Inland Steel Company, East Chicago, Indiana.
ROSS E. BEYNON, *Superintendent*, Roll Shop, South Works, Carnegie-Illinois Steel Corporation, Chicago, Illinois.
JAMES H. FRANZ, *Assistant to Superintendent Maintenance*, Carnegie-Illinois Steel Corporation, Youngstown, Ohio.
FREDERIC M. DARNER, *Chief Engineer*, Manufacturing Division, Republic Steel Corporation, Cleveland, Ohio.
WARREN E. HART, *Superintendent*, Electric Furnace Building, Ford Motor Company, Dearborn, Michigan.
ELMER F. WEISS, *District Manager*, Cutler-Hammer, Inc., Detroit, Michigan.
JOHN S. MORRIS, *Methods Engineer*, Lukens Steel Company, Coatesville, Pennsylvania.
H. K. HARDCASTLE, *District Manager*, Electric Controller and Manufacturing Company, Philadelphia, Pennsylvania.
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F. E. KLING, *Steel Mill Engineer*, 2240 Selma Avenue, Youngstown, Ohio.
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C. E. PRITCHARD, *Lubrication Engineer*, Republic Steel Corporation, Cleveland, Ohio.
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J. A. SHIMMIN, *Plant Engineer*, Operating Department, Rotary Electric Steel Company, Box 90, Mound Road, Detroit, Michigan.
C. H. WILLIAMS, *Chief Engineer*, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania.

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J. L. TATMAN, *Assistant to General Manager*, Wheeling Steel Corporation, Steubenville, Ohio.

FLOYD S. ECKHARDT, *Chief Engineer*, Bethlehem Steel Company, Lackawanna, New York.
D. N. EVANS, *Lubrication Engineer*, Inland Steel Company, East Chicago, Indiana.
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H. L. COE, *Assistant Maintenance Superintendent*, Carnegie-Illinois Steel Corporation, Clairton, Pennsylvania.
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R. W. GRAHAM, *Electrical Superintendent*, Bethlehem Steel Company, Lackawanna, New York.
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EVERETT C. HITE, *Combustion and Refractories Engineer*, Steel and Tube Division, Timken Roller Bearing Company, Canton, Ohio.
JOHN J. ALEXANDER, *Assistant Superintendent Power*, Republic Steel Corporation, Corrigan-McKinney Plant, Cleveland, Ohio.
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EDGAR A. HAWK, *Fuel Engineer*, Tennessee Coal, Iron and Railroad Company, Ensley, Alabama.
FRANCIS QUEEN, *Combustion Engineer*, Ford Motor Company, Dearborn, Michigan.
JACOB A. EKHARDT, *Superintendent of Fuels*, Wickwire, Spencer Division, Colorado Fuel and Iron Corporation, Buffalo, New York.

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P. E. HAGLUND, *Melting Superintendent*, Ford Motor Company, Dearborn, Michigan.
C. P. BETZ, *Assistant Manager*, Hanna Furnace Division, Great Lakes Steel Corporation, Ecorse, Detroit, Michigan.
ROY P. TOOKE, *General Superintendent*, American Rolling Mill Company, Butler, Pennsylvania.
ARTHUR K. BLOUGH, *Superintendent Electric Furnaces and Open Hearth*, Republic Steel Corporation, Canton, Ohio.
A. B. VESTAL, *Plant Industrial Engineer*, Carnegie-Illinois Steel Corporation, Duquesne, Pennsylvania.
JOHN S. STANIER, *General Superintendent*, Flat Rolled and Tubular Mills, Youngstown Sheet and Tube Company, Youngstown, Ohio.

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R. M. LANG, *Superintendent*, Rolling Mills, Atlantic Steel Company, Atlanta, Georgia.
JAMES N. IMEL, *Assistant Superintendent of Rolling Mills*, Jones and Laughlin Steel Corporation, Pittsburgh, Pennsylvania.
ANTON B. FROST, *Roll Designer*, Kaiser Company, Inc., Fontana, California.
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PAUL L. WALTER, *Mechanical Superintendent*, Republic Steel Corporation, Canton, Ohio.
JAMES J. HEALY, *Senior Mechanical Engineer*, American Rolling Mill Company, Middletown, Ohio.
L. J. GOULD, *Chief Engineer of Construction*, Bethlehem Steel Company, Bethlehem, Pennsylvania.
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GEORGE W. VREELAND, *Chief Construction Engineer*, Iron and Steel Division, Kaiser Company, Inc., Oakland, California.
PAUL F. KOHLHAAS, *Vice President*, Engineering Department, Columbia Steel Company, San Francisco, California.

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C. E. PRITCHARD, *Lubrication Engineer*, Republic Steel Corporation, Cleveland, Ohio.
R. A. BARTA, *Mechanical Foreman*, 88 in. Hot Strip Mill, Republic Steel Corporation, Corrigan-McKinney Works, Cleveland, Ohio.
WILLIAM E. HYDE, *Lubrication Engineer*, Wheeling Steel Corporation, Steubenville, Ohio.
DONALD E. WHITEHEAD, *Lubrication Engineer*, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania.
ANDREW CICHELLI, *Lubricating Engineer*, Bethlehem Steel Company, Sparrows Point, Maryland.
T. F. RAHILLY, JR., *Assistant to Works Manager*, Algoma Steel Company, Ltd., Saulte Ste. Marie, Ontario, Canada.
J. B. WHITLOCK, *General Maintenance Engineer*, The American Rolling Mill Company, Middletown, Ohio.

EDUCATIONAL COMMITTEE

Chairman: A. S. GLOSSBRENNER, *Assistant Vice President of Operations*, Youngstown District, Youngstown Sheet and Tube Company, Youngstown, Ohio.
ANDERS G. ERICSON, *Chief Engineer*, Homestead Works, Carnegie-Illinois Steel Corporation, Munhall, Pennsylvania.
J. H. VOHR, *Assistant General Superintendent*, Carnegie-Illinois Steel Corporation, Chicago, Illinois.

POWER AND POWER FACTOR IN *Arc Furnace Operation*

. . . . thorough knowledge of an arc furnace's electrical characteristics, with resulting proper control, can help attain more efficient and economical furnace operation . . . .

By E. H. BROWNING
Industry Engineering Department
Westinghouse Electric Corporation
East Pittsburgh, Pennsylvania

▲ DURING the last decade or so, considerable information having to do with the operation of direct-arc electric furnaces in regard to power and equipment requirements has been collected, presented, and published. The subject has thus been dealt with from the view points of power companies, furnace manufacturers, and electrical equipment manufacturers. For the greater part, the later papers prepared were directed at operators of electric steel making furnaces and have consisted of descriptions of electrical equipment and suggestions aimed towards improvement of furnace operation.

One of the important considerations in the operation of direct arc electric furnaces used for steel making is that of obtaining maximum power input to the furnace at the best power factor possible. At present, whether this condition for any particular furnace installation can be had depends in the majority of cases on the operator's ability to choose his tap voltage and adjust his electrode positioning regulator so as to exactly fulfill the requirements set down by the furnace electrical circuit characteristics. If conditions as dictated by these characteristics are satisfied, the benefits derived will be lower power cost per ton of product, high rate of production and the highest power factors commensurate with power inputs desired.

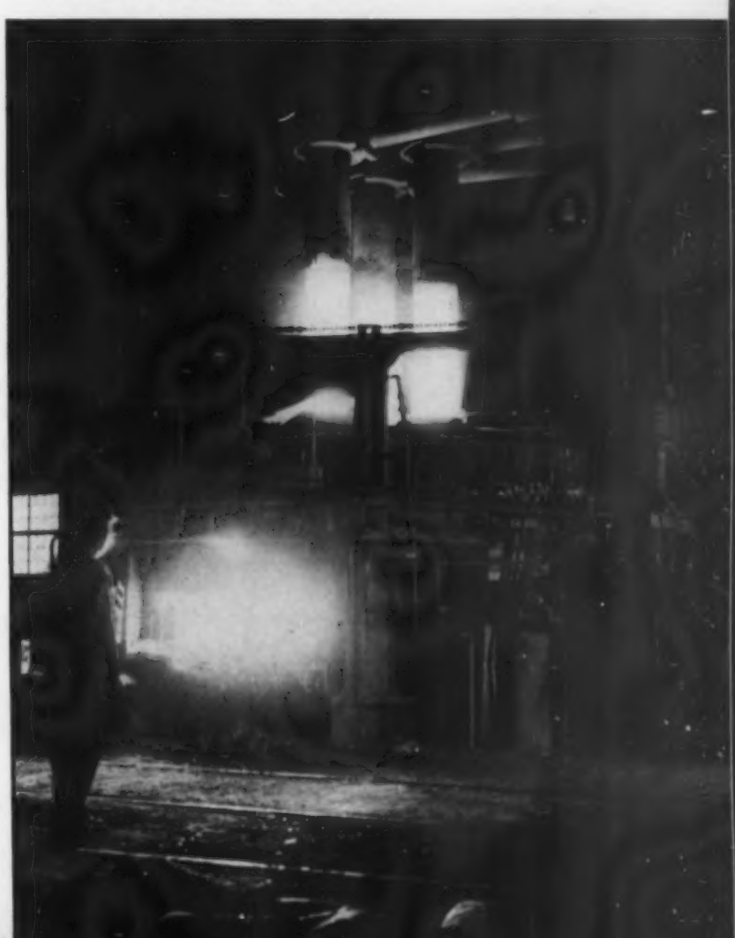
ELECTRICAL EQUIPMENT REQUIREMENTS

Three-phase electric furnaces of the direct-arc type range in size from about 500 pounds capacity at 250 kva to about 100 tons capacity at 20,000 kva; the latter rating being that of a furnace with six electrodes and using two transformers. Figure 1 shows a 10,000 kva electric arc furnace having a capacity of from 25 to 40 tons per heat depending on type of charge and steel produced.

The electrical equipment required for the satisfactory operation of such furnaces generally consists of the following, see Figure 2:

1. Disconnect switches.
2. A primary circuit breaker for use in repetitive interruption of magnetizing, normal and short circuit

Figure 1 — This furnace which produces from 25-40 tons per heat is rated at 10,000 kva.



Presented before AISE Annual Convention, Cleveland, Ohio, October 3, 1946

currents resulting from secondary circuit conditions. An air breaker is preferable and is recommended for this type of duty even though oil breakers have been and are still being used on a number of installations. The main objection to oil breakers is that frequent checking of the oil is required to prevent breaker failure and consequential shut down of the furnace because of carbonization of the oil and the subsequent lowering of insulation resistance due to the number of daily interruptions which may range as high as 40 to 100. Air insulated air blast switches have recently been developed for furnace installations of the order of 22,000 volts. These circuit breakers have been designed to withstand the severe repetitive mechanical duty at this higher voltage.

For interruption of primary circuit fault currents, a back-up breaker of either the air or oil type should be supplied for one or more furnaces.

3. A supplementary primary reactor with taps may be supplied if the reactance of the transformer and leads is not sufficient.
4. A transformer provided with taps to give the range of voltages specified for melting and refining the furnace charge.
5. A motor-operated no-load tapchanger.
6. Secondary copper bus work of ample section to conduct the heavy currents from the transformer to the leads of the furnace. These may be interlaced to reduce the inductive reactance.
7. A regulator for maintaining constant power input to the furnaces, and satisfactory operating conditions by automatically positioning the electrodes.
8. Direct current motors for motivating the electrodes as the furnace regulator dictates.
9. A direct current motor for operating furnace tilting mechanism.
10. An operator's control panel, control and protective equipment, and instruments for measuring furnace power, currents and voltages.

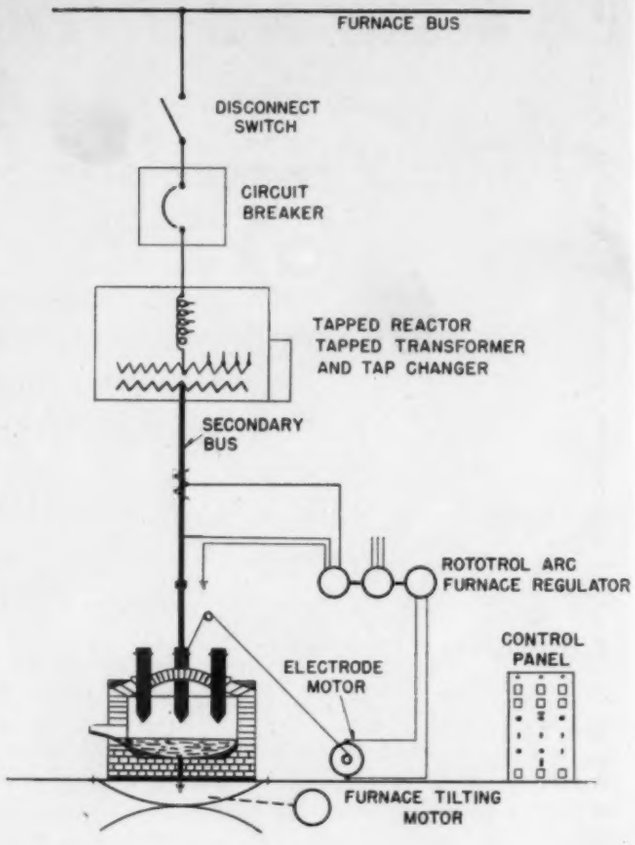


Figure 2 — The main electrical elements required for an electric arc furnace are illustrated in this sketch.

ARC CHARACTERISTIC, CIRCUIT REACTANCE, AND NATURE OF LOAD

The electric arc is the furnace entity at which the heat input to the furnace and its charge is generated. It is generally known that the electric arc has a negative current-voltage characteristic and is therefore of an unstable nature. Figure 3 shows that as the arc current increases, the arc resistance decreases and the voltage required to cause this increased current to flow is less than that required for the lower current value. With resistance or reactance, the voltage drop increases as the current increases; therefore, by adding sufficient amount of either of these in series with the arc, a combination circuit is obtained having in part a stable positive current-voltage characteristic where voltage drop increases as current increases. With this combination, for a given constant applied voltage the length of the arc determines the circuit current, stability and the power generated in the arc. Resistance, reactance, or a combination of the two could be introduced into the circuit to achieve the desired stability of the arc; however, the use of resistance would increase losses; therefore, reactance is the circuit element employed, and the resistance in the circuit, other than that of the arc, is only that which is inherent in the equipment and leads. This introduction or presence of reactance in the furnace circuit does lower the power factor of the load, but in addition to its effect on circuit stability, it also reduces current inrushes and short circuit currents common to furnace operation. It has been estimated that during the beginning of the melt-down of a furnace heat, as many as six to ten secondary short circuits per minute may be experienced; therefore, it is of great advantage for equipment protection and reduction of system voltage fluctuations to limit these currents from exceeding two to three times full load current.

The reactance of transformers utilized with small and medium size furnaces is not a very critical consideration, as the most economical design of the transformer for such an application presents a reactance value which is low, and hence requires that additional external reactance value which is low, and hence requires that additional external reactance be inserted in the circuit to aid in performing the function of providing sufficient impedance for arc stability and limitation of excessive current surges. For large furnace transformers, the reactance is usually kept to a minimum (4-5 per cent) by careful design, since the lead reactance encountered

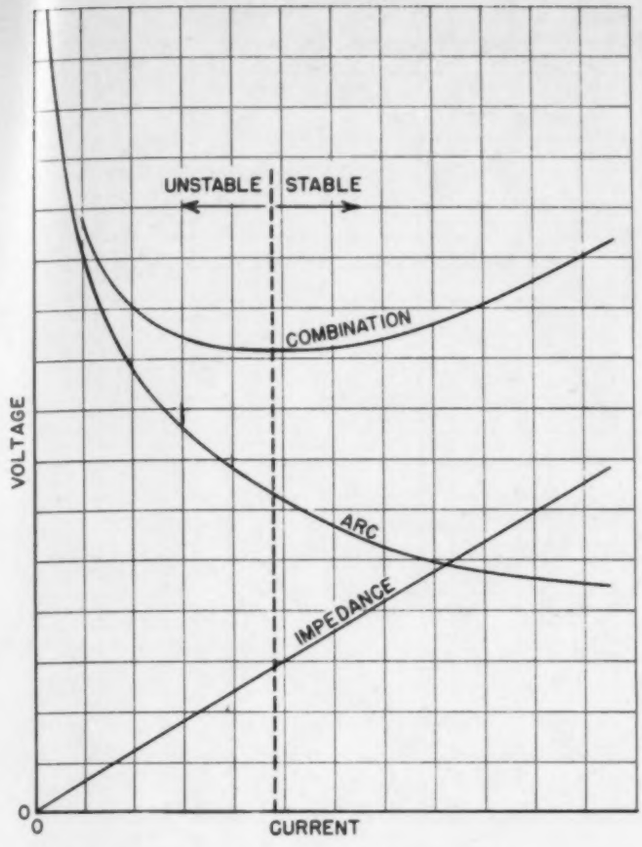


Figure 3 — Increased resistance or reactance increases the stability of the current-voltage relationship.

in their use is usually of comparatively great magnitude. Because of this latter fact, supplementary reactance is not, in general, necessary; on the contrary, in many installations interlacing of the secondary bus work must be accomplished to avoid having too much reactance in the circuit with subsequent inability to put the required power into the furnace. Table I gives typical values of supplementary reactance used in conjunction with various furnace ratings. The proper value of circuit reactance to be utilized with a given furnace installation to limit current inrushes to safe values and to assure stability is in most cases determined by experienced furnace designers and builders.

TYPICAL FURNACE CHARACTERISTICS

In a circuit containing both resistance and reactance and having a constant applied voltage, such as an electric arc furnace circuit, the theoretical maximum power input is obtained when the value of the circuit resistance equals the absolute value of the circuit reactance. This can be shown by differentiating the power equation and finding the value of resistance in terms of reactance which will give optimum or maximum power input. This is shown as follows for a single phase circuit:

$P = EI \cos \theta$

$I = E/z$, $\cos \theta = r/z$ and $z = \sqrt{r^2 + x^2}$

Then $P = E^2 \dfrac{r}{r^2 + x^2}$, where:

E	constant applied line voltage
I	line current
cos θ	power factor
r	circuit resistance (variable)
x	circuit reactance (constant)
z	circuit impedance (variable)

Now, $f(r) = E^2 \dfrac{r}{r^2 + x^2}$

Solving $f'(r) = k \dfrac{x^2 - r^2}{(r^2 + x^2)} = 0$; $r = +x$ or $-x$

$f'(r) = k \dfrac{(x - r)\ (x + r)}{r^2 + x^2}$ $\qquad$ k = a constant

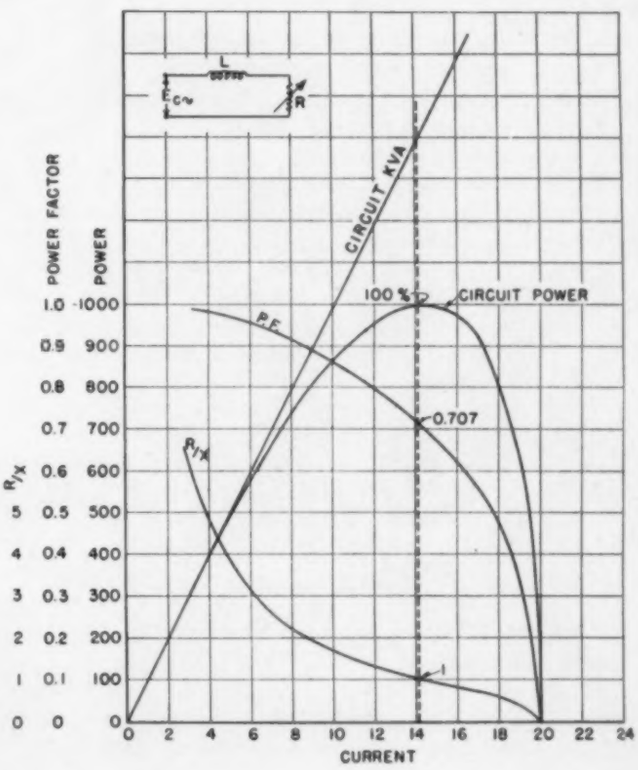
As r is increased through x in value, f′(r) changes from (+) to (−) thus indicating that power, the function of circuit resistance in this case, is maximum when the circuit resistance equals the circuit reactance in magnitude. At this condition of maximum power input,

$$\text{power factor} = \cos \theta = r/z = r/\sqrt{2}r = 0.707$$

The above condition for maximum power is shown graphically in Figure 4 for a circuit similar to a single phase furnace circuit. The mathematics and the curves show that, with a constant applied voltage, any decrease of circuit resistance (decreasing length of arc and increasing current) beyond a certain point results in no increase of power input to the furnace circuit but rather causes a decrease of power input with an increase in kva and a poorer power factor.

For a three-phase arc furnace such as is used in steel making, equations applying to best electrical operating

Figure 4 — The power factor at maximum circuit power is 0.707.



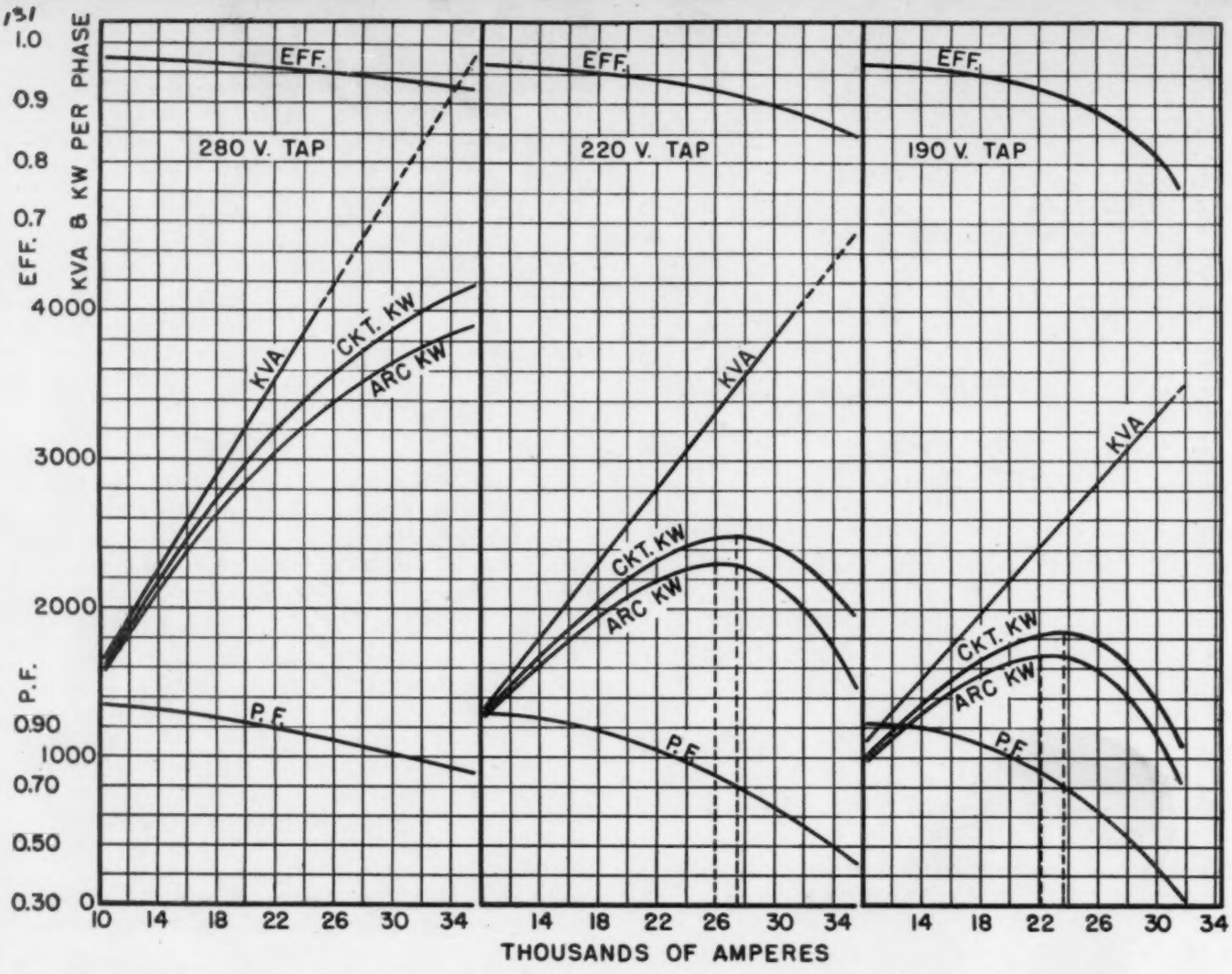


Figure 5 — These curves for power at various tap settings show that beyond a certain current value for each setting, useful power decreases, and efficiency decreases.

conditions may be set down as follows where:

P_a = useful power per phase
P_a max = maximum useful power per phase
E = phase to neutral voltage
I = phase current
x = circuit reactance per phase
r_L = circuit resistance (transformer and leads) per phase
r_a = resistance of arc per phase. The resistance of the charge is not readily calculated and contributes such a small portion of the generated heat that it is neglected in this analysis.

$$I=\frac{E}{\sqrt{x^2+(r_L-r_a)^2}}$$

$$P_a=I^2r_a=\frac{E^2r_a}{x^2+(r_L+r_a)^2}$$

By differentiation, it may be shown that $P=P_a$ max. when $r_a=\sqrt{r_L^2+x^2}$

Under this condition,

$$P_a \text{ max.}=I^2\sqrt{r_L^2+x^2}=\frac{E^2\sqrt{r_L^2+x^2}}{x^2+(\sqrt{r_L^2+x^2}+r_L)^2}$$

Therefore, the current producing maximum useful power is given as:

$$Ip_a \text{ max}=\frac{E}{\sqrt{x^2+(r_L+\sqrt{r_L^2+x^2})^2}}$$

The power factor for the furnace circuit is given as:

$$\cos\theta=\frac{(r_L+r_a)^2}{\sqrt{x^2+(r_L+r_a)^2}}$$

By substituting in this equation, the value of arc resistance corresponding to the condition for maximum useful power input, $r_a=\sqrt{r_L^2+x^2}$, the value of the power factor at the optimum useful input is found to be:

$$\cos\theta\ P_a \text{ max.}=\frac{r_L+\sqrt{r_L^2+x^2}}{\sqrt{x^2+(\sqrt{r_L^2+x^2}+r_L)^2}}$$

The furnace electrical efficiency for the condition of maximum useful power is given as:

$$\text{Efficiency } P^a \text{ max.}=\frac{\sqrt{r_L^2+x^2}}{r_L+\sqrt{r_L^2+x^2}}$$

Figure 5 illustrates the form of electrical furnace characteristics for various transformer tap settings. In these curves, the aforementioned facts are illustrated

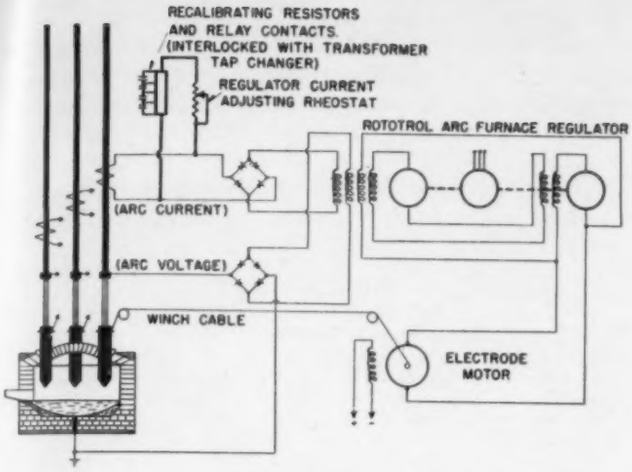


Figure 6 — The use of auxiliary relays and resistors in the control circuit is one way of prohibiting the use of excessive arc currents.

and some additional ones are evident. The points which should bear particular emphasis are:

1. An increase of current beyond a certain definite value results in a decrease of useful power, efficiency, and power factor.
2. Maximum useful power input to the furnace and maximum circuit power do not occur at the same value of current; the current producing the former being less than for the latter.
3. The power factor at the point of operation yielding maximum useful power is greater than that at the point of maximum circuit power (0.707).

The value of arc current corresponding to maximum useful power input to the furnace generally ranges from about 5 to 20 per cent less than that value of arc current presenting maximum furnace circuit power input. Also, since the power factor at maximum furnace circuit input is 0.707, it is obvious that for any condition of proper furnace operation, the power factor should be above this value. In this instance, proper furnace operation is defined as adjusting the furnace electrode positioning regulator such that the magnitude of the arc current maintained is equal to or less than that value providing maximum useful power input to the furnace.

The optimum values of arc current for the various operating tap voltages for a given furnace installation may be calculated if the values of the various circuit constants back to a point in the system where the voltage is maintained constant are known. However, this is not usually the case and for most practical purposes the magnitudes of these currents may be determined experimentally. It is true that the violent nature of the arc in an electric steel making furnace makes the correlation of instrument readings difficult, but there are short times during the melting period when such data can be collected. One experienced in furnace operation and familiar with the circuit characteristics can obtain, by trimming, the current adjusting rheostats of the regulator, balanced arc conditions and at the same time read the minimum value of arc current beyond which the wattmeter reading does not increase or begins to fall off. This value of current corresponds to maximum power input to the circuit on the load side of the point where the instruments are connected and includes circuit losses. By calculation or actual measurement, the value of the equipment and conductor resistance from the point in the circuit where the instruments are connected through the electrode can be obtained and the total I^2R loss exclusive of that generated in the arc can be evaluated and, with the iron losses if these are included in the power readings, subtracted from the circuit power input, thus yielding the useful power input to furnace. By reducing current slightly in steps at the same tap voltage and following the procedure given above, sufficient data are available to enable the plotting of a curve of useful power input against arc current. This will permit the determining of the one value of arc current which results in maximum useful power input to the furnace at the given tap voltage. This procedure can be followed through for all voltages employed in the operation of the furnace.

Another and perhaps better method entails the use of high speed graphic instruments for recording circuit power and current or voltage. With the furnace operating near the value of current which yields maximum circuit power, the form of the graph of circuit power shows the recurrence of peaks, of equal magnitude at all times. By reasoning that this maximum value of circuit power as shown on the chart occurs at 0.707 power factor, the value of reactance from the point where the instruments are connected into the circuit can be calculated. Since this value of reactance remains constant for a given transformer tap, various values of current can be assumed and calculations made of resistance and power. A curve of power versus arc current can then be plotted. By actual measurement of circuit resistance and by securing transformer iron losses, the total circuit losses can be computed and subtracted from the circuit power curve thus yielding a curve of useful power input versus current. From this curve the maximum value of current from the standpoint of power factor and maximum furnace power can be determined.

Knowing the values of the current which should be maintained for each voltage tap, the operator can note during periods of stable operation the settings of the regulator current adjusting rheostats and use these settings at times when operation is such as to make reading of the instruments very difficult.

METHODS FOR IMPROVING FURNACE ELECTRICAL OPERATION

Of great importance in the operation of direct-arc electric furnaces is the proper selection of tap voltages and corresponding arc current values. In the majority of cases, this is at present left to the judgment and discretion of the operator, and the results obtained depend in large measure on his experience and ability. The choice of the secondary voltage in part depends on the nature and form of the charge, heat receptivity of the charge, type and condition of the refractory, and bath agitation; but once a voltage has been selected, the arc current value resulting in maximum power input to the furnace at the best power factor is fixed by the furnace electrical circuit constants. Therefore, as an aid to the operator, it is advisable that a chart be posted

TABLE I

Typical Values of Supplementary Reactance for Arc Furnaces

Furnace size in tons	Transformer capacity, kva	% Reactor	
		60 C	25 C
7	3000—4000	15—20	25—30
10	3500—4500	15—20	25—30
15	5,000	10—15	20—25
25	10,000	None	10—15
40	12,000	None	None
100	2—10,000 or 2—12,000	None	None

on or near the control panel giving the maximum values of current as determined by test to be used with each tap voltage utilized during the heat.

One suggested method for helping the melter achieve the conditions of optimum power input at a satisfactory power factor concerns the use of three secondary single phase wattmeters in place of the presently used three single phase ammeters. The operator could then adjust his furnace regulator such as to obtain maximum input by reference to these wattmeters. This permits a more evident means of indicating the correlation between adjustment of the regulator current adjusting rheostats and the power input to the furnace.

The use of auxiliary equipment in the control circuit of the furnace electrode positioning regulator has been pointed out as being one method of prohibiting the use of excessive arc currents which result in less power input to the furnace and lower operating power factors. Such an arrangement consists of using relays and resistors such that the regulator is recalibrated for each tap voltage, so that the current which can be obtained is limited at the maximum at that value which results in the maximum power factor for the maximum power input to the furnace with that particular tap voltage. The operator can use a lesser value of arc current and obtain less power input to the furnace at a higher power factor, but his minimum power factor and maximum arc current are automatically limited for each operating voltage. This scheme has been tried on a furnace installation and has indicated an improvement in power factor over that which was previously obtained. Figure 6 illustrates the use of auxiliary relays and resistors in the control circuit of a rotating control type of arc furnace regulator. The resistors are placed in series with the shunt current adjusting rheostat such that the minimum resistance of this circuit is that of the resistor alone, this value of resistance having been chosen as that which causes the regulator to position the electrodes such that the arc length for each tap voltage results in that value of arc current corresponding to maximum useful power input to the furnace at the best power factor. It is recognized that the use of auxiliary equipment requires some additional maintenance; however, when the application of such equipment results in a definite gain, its use is fully justified.

In the way of summarizing, it appears the best approach to the problem of achieving satisfactory power factors and desired furnace power input comes about through determining by test the nature and constants of the electrical circuit of each furnace installation. Once this is done and necessary data have been collected, characteristic curves of the given furnace electrical circuit may then be plotted and the conditions for optimum operation established. These curves will indicate differences in magnitude and condition between total circuit power and the useful power actually available in the furnace. Information thus obtained can be used as an aid for the furnace operator or for the application of auxiliary equipment to the furnace regulator such that improper operation is automatically prevented.

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DISCUSSION

PRESENTED BY

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T. B. MONTGOMERY, Engineer in Charge of Control Engineering, Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin

H. W. POOLE, Steel Mill Application Engineer, Industrial Engineering Department, General Electric Company, Schenectady, New York

C. W. VOKAC, Manager, Hydro-Arc Electric Furnace Section, Foundry Equipment Department, Whiting Corporation, Harvey, Illinois

GEORGE SCHAEFFER, JR., Electrical Engineer, Carpenter Steel Company, Reading, Pennsylvania

A. J. F. MacQUEEN, Electrical and Mechanical Superintendent, Atlas Steels Limited, Welland, Ontario, Canada

L. A. Wynd: This paper emphasizes the well known fact that power factor is the gage we must use to tell us when we approach maximum input of power to the arc.

New types of automatic control which maintain constant power input to the furnace are now beyond the development stage. One plant is actually operating electric furnaces with these controls and producing an average of fifteen tons of ingot steel per hour of furnace operation. Super-speed controls developed in recent years for direct current motors combined with contact making kw and kva integrating meters form the basis of these controls.

Operations and grades of steel in electric furnace plants are so varied that it is not practical to prescribe the same remedy for increasing production to all. Obviously the plant working with a high percentage of hot metal is not faced with the same problems as the one on 100 per cent cold charge.

The electric furnace situation in its present stage is a wonderful field for electrical, mechanical, and metallurgical engineers of inventive mind.

Much remains to be done in the field of reactance control. A certain amount of reactance for arc stabilization is necessary, but we certainly can and must reduce power losses in that part of the circuit. Building of the secondary leads in cylindrical arrangement and shortening the distance between furnace electrodes and the transformer will work wonders with this problem. Air cooled transformers are going to have to be considered on future installations. These will very likely be placed above and a short distance to one side of the electrodes, very materially shortening the length of the secondary. These units will be kept under pressure with cooled filtered air.

Air breakers have improved operations so much that they are definitely here to stay. We can expect further important developments in these auxiliaries. Trends are definitely toward improved equipment, circuit improvements, and automatic power factor control.

T. B. Montgomery: It seems to me that there is no field in which the electrical engineer supplies equipment that he knows less about than of this arc furnace operation. There are legitimate reasons for this. An arc furnace is an instrument for making steel, as opposed to the induction furnace which is for melting steel. The electrical conditions in a 3-phase arc furnace are complex due to the floating neutral and, therefore, difficult from the viewpoint of complete analysis. The problem is confused further because of very rapid and wide fluctuations in current and voltage.

Of the electrical equipment, circuit breakers and transformers have become relatively standard. Since furnace operation is so dependent on control, the responsibility of the engineer of this apparatus is out of proportion to that of the designer of the rest of the equipment, yet the price of the control is proportionately less than other parts of the equipment. The manufacturer then cannot afford much research.

The control of power factor is, as was brought out in the paper, designed to put the most average heat into melting per unit of power supplied.

Thinking about power factor, I would like to offer this one little thought, that the selection of voltages actually is in the hands of the operator because he has the job of making the kind of steel that he wants to. It is not in our hands.

I believe it will be a great help if we can control the power factor, but in thinking about the problem it is dependent, it seems to me, quite a bit on the conditions that we have in the furnace.

With a basic furnace where there is a nice, conductive slag, very little control is needed, and in that case we need to run with the minimum amount of reactance in order to get the minimum kilowatt hours per ton. On the other hand where the electrodes are operated on "bare metal" as in refining steel, a large reactance is required to prevent excessive hunting and efficiency is sacrificed.

Another factor that we do not take into consideration is the inductance of the secondary leads. It is rather fixed, and therefore we are not in a position to reduce the power factor to a great extent, that is, below certain minimum standards, particularly in large furnaces.

In other words, from the point of view of the designer we are looking for minimum power, but from the point of view of the metallurgist and the operator we are looking for a stable condition. We, therefore, do not necessarily set the electrical circuits at the point of best efficiency.

These comments are offered merely to convey the idea that in the writer's opinion there is considerable knowledge not yet available which will help us to better furnace operation. Therefore, with further study of data from all sources, with cooperation of metallurgist and electrical designer, it is believed that further benefit will derive to the industry. A cooperative program might pay dividends.

H. W. Poole: The author has done a good job of emphasizing the fundamentals of arc furnace operation. A lot more can be done to reduce costs and to turn out better steel in a shorter time if we stick closer to fundamentals.

One thing that was mentioned was the possibility of using recalibrating relays in the regulating circuit in order to limit the maximum input to the furnace, and prevent the operator from running the arc current at too high a value, and it was mentioned that it might complicate the circuit somewhat. We have built approximately fifty rotating regulator controls incorporating this feature, and in the case of a four position tap changer only three extra interlocks and three extra wires are required. It is really worthwhile because you can absolutely prevent the operator from passing the point of maximum power input to the furnaces.

The author also made short mention of an air-blast breaker for the higher voltage circuits, and I would be interested to know if he feels that the use of the air-blast principle in interrupting transformer magnetizing current is more desirable than some of the other possible ways which are in use.

Charles W. Vokac: The three largest electrical manufacturers have made great strides in improving the regulators used on electric-arc furnaces, but until the time my company was organized, there apparently has been less done on the mechanical part of the regulator which is half of the furnace regulation equipment. The founder of our company, Mr. Payne, knowing the requirements of these tools realized that the winch drives used with furnace regulators were not as accurate as even the electrical regulators designed at that date. Since then, these electrical regulators have been improved considerably.

The idea was to reduce the size of the control because

better regulation could be obtained with smaller, less cumbersome equipment. This was done by counterbalancing the weight of the electrodes, electrode arms, cables, etc., with a means that has a very low inertia (air-counterbalancing). By doing this and applying a unique hydraulic system which is inherently very efficient, it was possible to reduce the size of the electrode motors from one-half to one-quarter and double the electrode speeds. This hydraulic, air-counterbalanced electrode positioning equipment responds instantly to every demand of the finest regulator built to date. This mechanical regulator is just one-half of the chain of equipment in the regulation of an electric-arc furnace, and is at least equal in efficiency to the other half. The use of this control will enable you to improve your power factor and reduce your circuit breaker cut-outs to the minimum for which these breakers are built. There is practically no lost motion in the system; the hydraulic fluid is practically incompressible; the electrode motors are the same type as those conventionally used, are directly connected to a metering pump which measures and conveys the hydraulic fluid to a cylinder, which in turn accurately positions the electrode. The metering pump eliminates the uncertainty of friction and the effects of variable electrode and cable weights.

George Schaeffer, Jr.: Talking about these air breakers, I thought you might be interested in some experience we have had with two air breakers (one used as a spare) put on one of our 12-ton furnaces three years ago. We believe that they were among the first used in the country. Each of them has operated about 50,000 times since 1943, and it was just about two months ago that we replaced worn parts on them. Some of the contact fingers wore and the pins also wore a little, but we have had no maintenance troubles at all, except to look at them once in a while to see that they are in shape.

A. J. F. MacQueen: We have done some work with our furnaces along the lines indicated, not so much because of power factor, but with a view to reducing the time of heats.

We attempted to obtain the necessary data by getting simultaneous records of voltage current and kw on standard recording meters, using a high speed chart. The meters were connected to the transformer secondary, and a series of records were obtained covering a variety of furnace conditions.

The results were reasonably consistent as far as kw and ampere relationship went, and we obtained a reasonably accurate determination of the value of current for maximum transformer kw output. The power factor calculations were rather erratic and we found that, whereas the calculations and charts in Mr. Browning's paper are based on constant voltage supply, in practice the power line voltage regulation makes it difficult to get accurate results.

As was pointed out in the paper, the transformer maximum kw output is not the same and does not occur at the same current value as maximum furnace kw input. We attempted to calculate the furnace input, but could not get what we considered reliable values of secondary resistance. We had found that maximum transformer kw output occurred at approximately 33,000 amp on the high voltage tap, and in the light of the available data we simply made a guess at the current value for maximum furnace kw and arbitrarily set up a maximum value of 30,000 amp for the furnace operators. We found it unnecessary to set maximum values for the lower taps. A check on the time of heats for corresponding grades of steel shows a definite improvement as a result of this step. However, an accurate means of determining secondary resistance so as to get accurate values of furnace kw would be more satisfactory.

The use of wattmeters instead of ammeters has been proposed at various times. A great many operators do not know what an ampere or a kilowatt is. They learn to operate the furnaces according to the numbers on the scale, and whether amperes or kilowatts, it's simply a matter of what the operators become accustomed to. In any case, the meters indicate transformer output, and would have to be recalibrated, or a conversion chart used, to get furnace input and a conversion chart would not be very satisfactory.

I believe the best way to control the power factor is to put a limiting device on the furnace regulator. The increased maintenance is not a big factor, and such a device is reasonably fool-proof and does not require extra attention from the operator.

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I believe the best way to control the power factor is to put a limiting device on the furnace regulator. The increased maintenance is not a big factor, and such a device is reasonably fool-proof and does not require extra attention from the operator.

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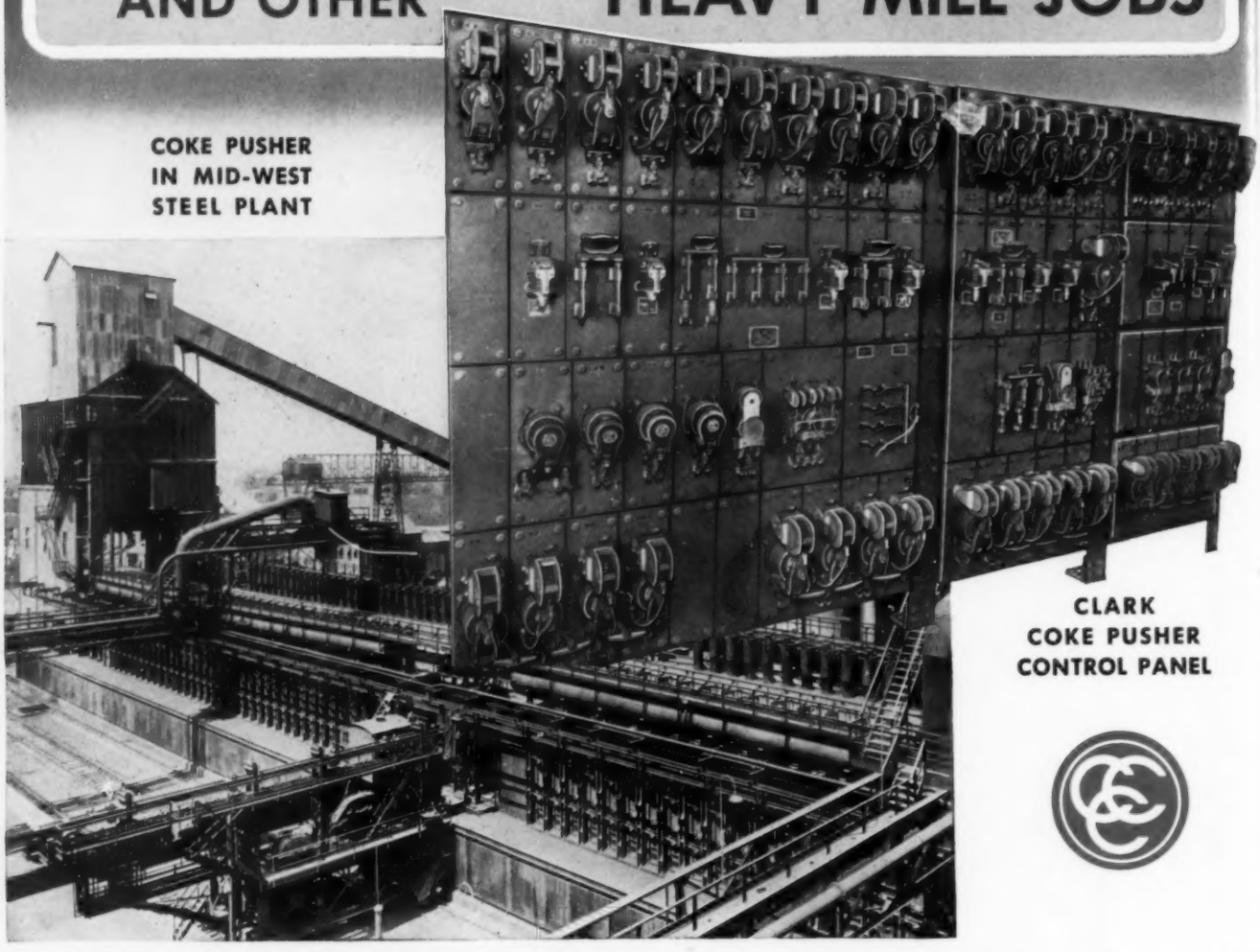

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The Modern Coke Plant

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By T. J. Ess

▲ COKE, the product of coal heated in the absence of air, has been known to mankind for more than 2000 years, and was used to a limited degree through the middle ages. It was not until the sixteenth century, however, that much reference to coke production is found. At that time, coal was coked in piles covered over with dirt, wet straw or leaves, or wet coke breeze. Flues were formed in the pile by large lumps of coal or by withdrawing wooden posts around which the coal had been piled. Coke yield was about 33 per cent of the coal carbonized. Later, a permanent refractory chimney was used in the center of the pile.

Gradually, brick walls were applied to confine the pile, and air ports and chimney flues built into the walls. The top of the coal was covered with fine, wet coke or dirt. Coking time was about eight days, and two more days were necessary for cooling before drawing the coke by hand. The coke yield had gradually increased to about 55 per cent of the coal carbonized.

Finally, the beehive oven was developed, which was essentially a permanent refractory container in which the coking pile was placed.

BEEHIVE OVENS

Beehive ovens are now essentially hemispherical in shape, approximately 12 ft in diameter and 8 ft high, and are built of highly refractory brick, covered over with loam. An opening in the top of the oven permits the charging of coal and the escape of waste gases, while a door is left at the bottom of the oven for watering and drawing the coke, and for admitting air for combustion.

When the oven is hot and ready for charging, coal is charged into the oven and leveled to a depth of 2 to 2½ ft, and the door is bricked up almost to the top.

The charging pulls down oven wall surface temperature to perhaps 600 to 700 F, but heat stored in the brick work soaks in and the temperature gradually rises.

As heat from the oven brickwork reaches the coal, the volatile matter begins to distill off and soon ignites (at about 1200 F), burning with the air brought in through the door. The volume of volatile matter driven off gradually increases, holds steady for awhile, and then drops off. The opening at the top of the door must be gradually closed up as the volatile decreases, so as to regulate combustion and maintain oven temperature at a maximum of 2000 to 2200 F. Too much or too little air lowers the temperature. The correct amount is 0.8 to 0.9 of the quantity required for complete combustion of the gas driven off. Gas leaving the oven should contain 2 to 4 per cent CO and less than one per cent O_2.

Coking proceeds from the top of the coal downward, so that coking time depends principally upon depth of the coal. A depth of about ½ in. is coked per hour, so that coking time is usually 48 to 72 hours. When evolution of volatile matter stops, as shown by subsidance of smoke issuing from the oven top, the coke is sprayed with water, and raked out of the oven. During quenching, oven wall temperature is reduced to 800 to 900 F.

Beehive ovens will coke 2 to 2.5 lb of coal per hr per sq ft of oven floor area, with a coke yield of about 65 per cent. The coke is silvery gray in color, and has a long columnar structure.

Mechanization of beehive oven installations in some cases included a charging car running along the tops of the ovens, a drawer or pusher car running along one side of the ovens, and a car-leading conveyor along the other side. Some reclamation of the gases driven off was practiced in some plants. One method was to gather the gases into a common flue for use under boilers. In other instances the expelled gas was burned in flues under the oven floor to provide heat for the coking process.

Gradual recognition of the tremendous waste of valuable by-products in beehive coking led to experimenta-

TABLE I

STATISTICS OF COKING INDUSTRY

	1937	1942	1943	1944	1945	1946
Coke production:						
By-product	49,210,748	62,294,909	63,742,676	67,064,795	62,094,288	53,929,447
Beehive	3,164,721	8,274,035	7,933,387	6,973,022	5,213,893	4,568,401
Total	52,375,469	70,568,944	71,676,063	74,037,817	67,308,181	59,497,848
Coke use:						
Furnace	36,751,969	55,491,570	57,690,160	57,481,353	51,022,921	43,700,492
Foundry	2,038,822	2,591,576	2,606,889	2,511,854	2,636,731	2,996,202
Other industrial	4,597,894	6,598,842	6,999,884	6,978,062	6,937,553	6,593,870
Domestic	8,107,518	6,061,694	4,885,528	6,717,543	6,775,508	5,096,733
By-product yields per ton of coal:						
Tar, gal	8.67	8.41	8.11	8.13	7.95	7.82
Ammonium sulphate or equivalent, lb	21.84	20.85	20.32	20.29	20.22	19.79
Crude light oil, gal	2.86	2.88	2.83	2.87	2.84	2.77
Surplus gas, cu ft	6660	6650	6590	6580	6330	6290
Ovens at end of year:						
Slot type in existence	12,718	13,303	14,253	14,580	14,510	14,494
Beehive in existence	12,194	16,295	17,666	16,318	12,179	12,864
Slot type under construction	259	1327	528	180	335	824

tion to reclaim these by-products. Through the nineteenth century, the by-product oven was gradually developed in Europe, and in 1892 the first by-product ovens were built in the United States at Syracuse, New York. The first by-product ovens for the production of blast furnace coke were built at Johnstown, Pennsylvania, but progress was slow.

As a matter of record, the first American use of coke in a blast furnace was in 1835 at Mary Ann furnace in Huntingdon County, Pennsylvania. Blast furnace fuel, however, consisted principally of charcoal and anthracite coal until about 1875, when the use of coke became more widespread.

Up until 1893, all coke in the United States was made in beehive ovens, and for a considerable period of time after that the demand for coke continued to grow faster than the by-product oven was adopted. In fact, the maximum production of beehive coke in the United States occurred in 1916, when 35,464,000 tons (65 per cent of total U. S. production) were made.

As of January 1, 1947, there were in the United States 14,494 by-product ovens in 87 plants, with a total annual capacity of 71,112,600 net tons of coke. Of these, 11,289 ovens, totaling 56,653,100 net tons capacity, are located in 55 furnace plants, while the remainder are in merchant plants. In addition to these existing ovens,

Figure 1 — Cross-section through a mechanized beehive coke oven, showing charging car, pusher, and car-loading conveyor.

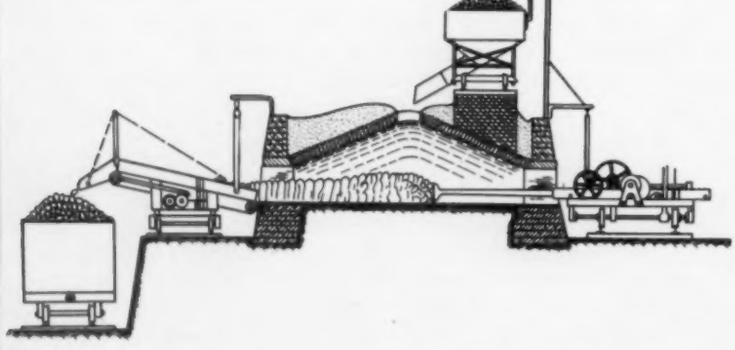


TABLE II

STATISTICS OF BY-PRODUCT COKE INDUSTRY, 1946

Coal charged to ovens, net tons:	
Bituminous	76,120,674
Anthracite	238,812
Total	76,359,486
Coke produced, net tons:	
At merchant plants	12,388,485
At furnace plants	41,540,962
Total	53,929,447
Average yield per cent of coal charged:	
Coke (total)	76.17
Breeze	5.54
Coal chemical materials produced:	
Tar, gal	596,868,745
Ammonia sulphate or equivalent, lb	1,487,434,225
Total gas make, M cu ft	783,637,016
Gas burned in coking, per cent	37.48
Surplus gas sold or used, per cent	61.32
Gas wasted, per cent	1.20
Crude light oil, gal	206,914,333
Yields per ton of coal:	
Tar, gal	7.82
Ammonium sulphate or equivalent, lb	19.79
Gas, cu ft	10,260
Crude light oil	2.77
Light oil derivatives, gal:	
Benzol, motor	27,398,866
Benzol, other grades	109,728,963
Toluol, crude and refined	16,519,763
Xylol, crude and refined	5,986,250
Solvent naphtha	4,401,158
Other light oil products	7,572,226
Total	171,607,226
Crude, naphthalene, lb	71,605,138
Pyridine, gal:	
Crude	329,661
Refined	95,343
Picoline, gal	25,412
Sodium phenolate	2,448,547
Value of coal charged	$ 440,543,500
Value of coke at ovens	$ 450,060,212
Value of breeze	$ 11,717,566
Value of tar	$ 25,122,032
Value of ammonia	$ 19,442,059
Value of Surplus gas	$ 83,184,679
Value of light oil and derivatives	$ 25,581,473
Value of other coal chemical derivatives	$ 9,897,527
Total value of coke and breeze produced and by-products sold	$ 623,005,548

TABLE III

STATISTICS OF BEEHIVE COKE, 1946

Coal charged to ovens, net tons:	
Bituminous	7,167,424
Coke produced, net tons	4,568,401
Average yield, per cent of coal charged:	
Coke	63.74
Breeze	2.92
Value of coal charged	$25,722,680
Value of coke	$36,669,170
Value of breeze	$ 113,796

there were under construction 824 additional ovens with a capacity of 4,453,800 net tons of coke per year.

At the same time, there were 12,864 beehive ovens, with a total capacity of 8,427,000 net tons of coke per year, still in existence in 68 plants, principally in Pennsylvania.

Table I gives some statistics of the coking industry for several years, while Tables II and III give detailed statistics for 1946 for by-product and beehive coking, respectively.

COKING COAL

Approximately 16 per cent of the total bituminous coal produced in the United States is converted into coke. In the early days of the coke industry, high grade coking coals were plentiful, but reserves of these coals are gradually giving out, with the result that less desirable grades must be used. Sulphur and ash contents have gradually increased through recent years, and there is much activity to find and develop new coals suitable for coking. The blending of two or more coals has made enormous coal reserves suitable for coking.

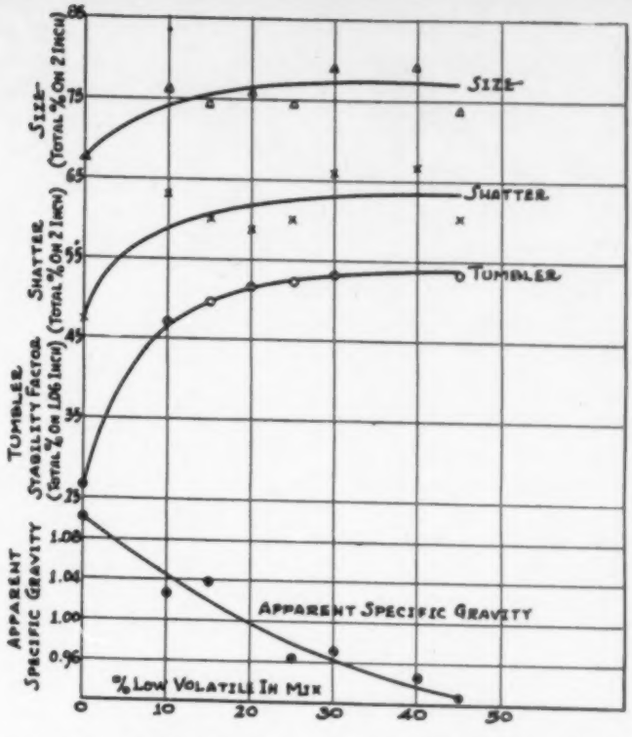


Figure 2 — Curves showing variations of physical properties of cokes with varying proportions of low-volatile coal in the coal mix.

Coking coals are mined in Pennsylvania, West Virginia, Virginia, Kentucky, Alabama, Colorado and Utah. Typical analyses are shown in Table IV.

Pennsylvania coals, with few exceptions, are so high in volatile matter that they should be mixed with 10 to 20 per cent of low-volatile coal if good physical coke is

TABLE IV

ANALYSES OF TYPICAL COKING COALS

State	County	Bed	Analysis									Btu per lb	Mine
			Proximate				Ultimate						
			Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulphur		
Pennsylvania	Allegheny	Pittsburgh	1.6	34.2	56.7	7.5	5.4	77.8	1.6	6.6	1.1	13,810	Ocean No. 2
Pennsylvania	Fayette	Pittsburgh	1.9	33.6	57.0	7.5	5.2	77.4	1.6	7.3	1.0	13,910	Edenborn
Pennsylvania	Fayette	Pittsburgh	1.0	33.6	56.9	8.5	5.3	77.0	1.6	6.3	1.3	13,820	Allison
Pennsylvania	Allegheny	Thick Freeport	2.2	36.3	55.2	6.3	5.5	76.9	1.5	8.5	1.3	13,870	Wildwood
Pennsylvania	Allegheny	Pittsburgh	1.8	35.1	57.7	5.4	5.3	79.0	1.6	7.8	0.9	14,140	Warden
West Virginia	Logan	Chilton	2.2	36.2	57.3	4.3	5.4	79.3	1.5	8.9	0.6	14,200	Boone No. 2
West Virginia	Marion	Pittsburgh	1.9	37.3	54.8	6.0	5.5	77.9	1.6	8.4	0.6	14,010	Consolidation No. 63
West Virginia	Raleigh	Sewell	1.3	20.8	75.8	2.1	4.9	86.8	1.7	3.7	0.8	15,190	Cranberry No. 3
West Virginia	Fayette	Sewell	1.9	26.5	69.2	2.4	5.2	84.6	1.6	5.7	0.5	14,970	Summerlee
West Virginia	Kanawha	No. 2 Gas	1.9	38.8	56.6	2.7	5.5	80.3	1.4	9.2	0.9	14,450	Point Lick No. 4
West Virginia	Boone	Alma	2.1	37.7	53.1	7.1	5.4	76.8	1.5	7.4	1.2	13,810	Spruce River No. 4
West Virginia	McDowell	Pocahontas No. 4	0.8	15.4	79.0	4.8	4.3	86.7	1.1	2.6	0.5	14,870	Consolidation No. 251
Kentucky	Letcher	Elkhorn	2.2	36.6	59.0	2.2	6.1	80.9	1.5	8.7	0.6	14,410	Consolidation No. 204
Kentucky	Muhlenberg	Green River	10.1	36.2	47.0	6.7	5.8	66.8	1.5	16.7	2.5	11,980	Green River
Virginia	Wise	Taggart	1.7	36.1	59.5	2.7	5.9	82.5	1.5	6.8	0.6	14,770	Roda No. 3
Maryland	Garrett	Davis	1.4	22.1	66.7	9.8	5.0	77.7	1.5	4.5	1.5	13,820	Arnold
Illinois	Franklin	No. 6	7.9	32.1	47.7	12.3	5.1	65.5	1.4	14.9	0.8	11,540	Orient No. 1
Alabama	Jefferson	Mary Lee	1.2	27.9	55.0	15.9	4.6	71.4	1.5	5.8	0.8	12,600	Flat Top
Alabama	Walker	Black Creek	3.1	36.0	58.3	2.6	5.7	79.2	1.7	9.7	1.1	14,190	Empire
Alabama	Jefferson	Pratt	1.5	30.1	59.2	9.2	5.0	77.1	1.6	6.4	0.7	13,730	Wylam No. 8
Utah	Carbon	Lower Sunnyside	4.6	38.8	50.6	6.0	5.7	72.9	1.5	12.9	1.0	13,030	Columbia
British Columbia	Canada	B	1.4	27.0	65.4	6.2	4.9	80.8	1.3	6.2	0.6	14,240	Michel

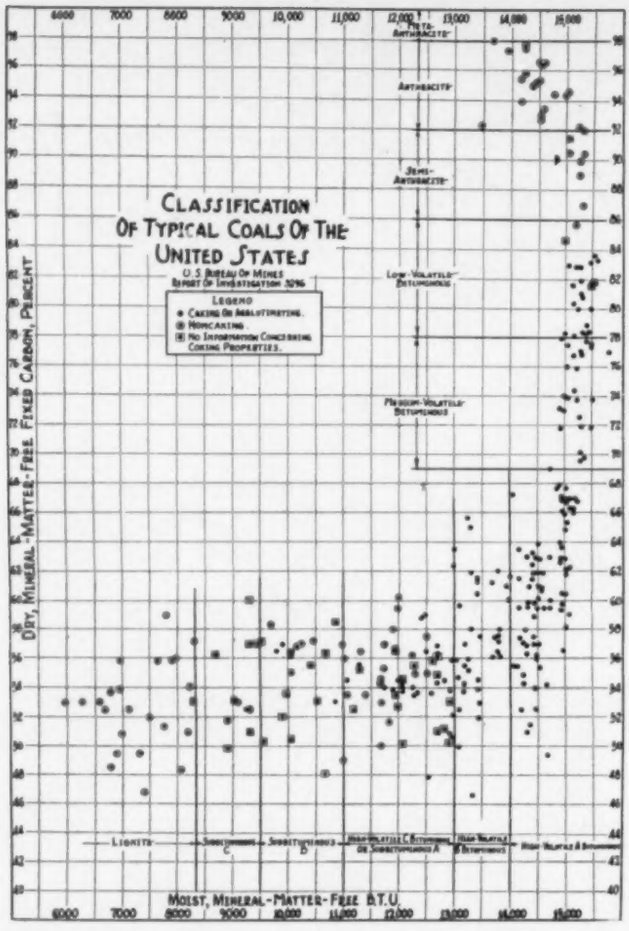


Figure 3 — Classification of typical coals of the United States.

wanted. In lake plants, such mixing makes little difference in cost, as freight costs on high and low volatile coals are about the same. In the Pittsburgh and valley districts, however, low-volatile coal increases the cost of the coal mix very materially. This increase in coke cost may be offset by improved blast furnace operation, but the majority of Pittsburgh district plants use only high-volatile coal.

The suitability of a coal for producing metallurgical coke depends on many properties and characteristics. Volatile matter, ash and sulphur contents are of primary importance. Coals of very high-volatile content result in coke of relatively low strength, and they are generally used in a blend with low-volatile coals. Low-volatile coals have a tendency to expand when heated, and yield somewhat lower quantities of by-products.

Ash in the coal is of course carried over into the coke. Ash content of coke is about 1.35 times that of the coal charged to the oven, and high-ash coke is said to reduce iron production by about 5 per cent for each per cent of ash.

Between 60 and 70 per cent (usually 62 per cent) of the sulphur in the coal remains in the coke.

Coke of best quality is made from coals of relatively low oxygen content. More than 8 per cent oxygen on a dry ash-free basis will not make good commercial coke, although higher oxygen coal is used in some cases. Some authorities state that a hydrogen-oxygen ratio of 0.6 or more is desirable, with 0.55 a minimum value. Volatile matter should fall between 28 and 35 per cent on the dry, ash-free coal, although coals of higher volatile content are often used, but at the expense of the strength of the coke.

Excessive moisture in the coal may injure the oven brickwork; 7 per cent may be taken as a maximum. Low ash is desirable — the lower the better, not over 10 per cent, if possible. Sulphur should also be as low as possible, preferably not over 1.2 per cent for coke for blast furnace use, and 1.0 per cent for coke for foundry use.

Considerable progress has been made in the cleaning of coal. Many coals with high ash and sulphur contents can be rendered satisfactory by washing. Ash may be reduced by 15 to 30 per cent (as high as 50 per cent has been reported), sulphur by 10 to 20 per cent, or even as much as 40 per cent, phosphorus by 15 to 25 per cent, and refuse by 85 to 90 per cent. About one per cent of good coal is lost in the process. Results of coal washing have been reported as increased yields of coke and by-products, a 10 to 15 per cent improvement in physical and chemical qualities of the coke, and a 20 per cent reduction of hydrogen sulphide in the gas. In the blast furnace, this improved coke resulted in reductions of 5 to 8 per cent in coke consumption, 5 to 10 per cent in flux consumption, and 7 to 12 per cent slag volume, while iron production increased 5 to 8 per cent, and sulphur in the iron dropped.

The quantity of water used for washing runs 1.5 to 3.0 times the weight of coal washed. Moisture remaining in the washed coal may run 5 to 15 per cent.

During the coking process, coals may undergo marked changes in volume. Some coals may expand, while others contract, and there is no way to predict exactly which way a coal will behave except by actual test. In general, low-volatile coals expand and high-volatile coals contract, even though the coals come from the same seam. Tests of coals from the Lower Kittanning seam show 40 per cent or more expansion with 17 to 18 per cent volatile matter, and 27 to 30 per cent contraction with 42 per cent volatile. At approximately 31 per cent volatile, there seems to be no volume change.

Figure 4 — Modern metallurgical coal washing plant.

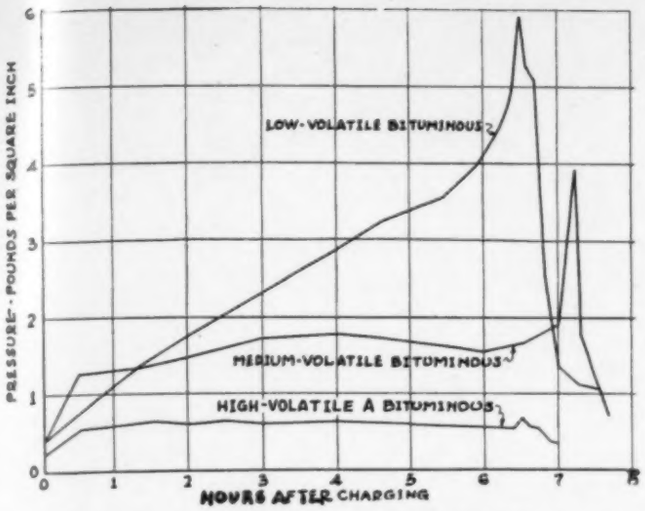


Figure 5 — Pressures developed by three typical coals during coking in movable-wall expansion oven.

Similar tests on coals from No. 3 Pocahontas seam shows 20 per cent expansion with 17 per cent volatile matter and 3 per cent expansion with 24 per cent volatile. All volatile contents in these tests are reported on the dry ash-free basis.

Since expanding coals may exert dangerous pressures against the oven walls, it is necessary that such coals be used in blends with coals that contract while coking, so that the final mixture is approximately neutral. Even then care must be used not to vary coking practice, as mixtures which may be safe when coked for long times at low temperatures may be dangerous at faster coking rates with higher temperatures. Likewise, the expansion of a coal or a coal mixture will increase if the bulk density of the charge increases. Finer pulverization and increased moisture (up to 7 per cent) tend to reduce density and hence, reduce expansion during coking.

Various methods have been devised for measuring the expanding properties of coal, running principally toward a miniature oven in which actual plant heating conditions are approximated, and which is provided with means for measuring actual pressure developed during the coking process.

A typical unit of this type is a test oven having a movable wall so arranged that the pressure caused by the expansion of coal may be measured in pounds per square inch. The oven holds about 400 lb of coal. Instruments are provided to measure the temperature of the coke across the oven width, and openings are left for measurement of heating flue temperature by optical pyrometer. The test oven is charged from an overhead hopper, and is raked out by hand.

Pressures developed by coals may range somewhat as follows:

High-volatile bituminous — ½ to ⅔ psi, remaining more or less constant through the coking process.

Medium-volatile bituminous — From ½ psi at charging to 1¾ psi at ½ hr, remaining rather constant except for a sudden peak of 4 psi at 7 hr.

Low-volatile bituminous — From ½ psi at charging up to 6 psi at 6½ hr. The occurrence of pressure peaks in an otherwise uniform pressure record shows that ovens may be damaged even though badly sticking ovens are not encountered in pushing.

The most accurate and reliable method of evaluating coking properties of coal is by full-scale oven tests. Less costly and easier to make are box tests, wherein a metal box full of the coal to be tested is embedded in a regular oven coal charge, but such tests may be misleading and are therefore generally used only for preliminary tests. Various methods of laboratory testing have been developed, and such tests provide information on coking properties, but are not the final answer.

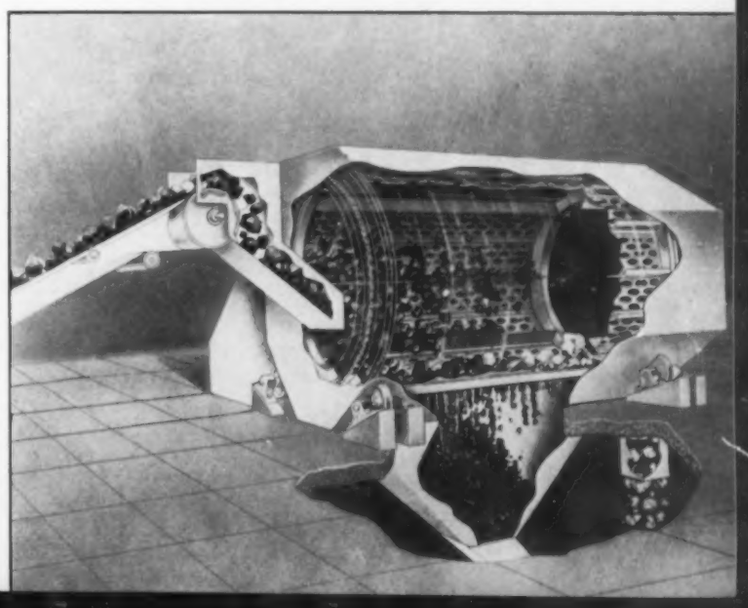
COAL HANDLING

As might be expected from the quantities of material involved, handling is a very important item in the coke plant, and an efficient, well-designed system for handling coal is essential for economical operation. Although details of layout must vary to suit the conditions in each plant, the problem has been satisfactorily met by a combination of hoppers, bins and belt conveyors that is fairly well standardized.

Coal from hopper cars is dropped into track hoppers 12 to 15 ft wide × 40 ft long, and fed by a shaker feeder onto a conveyor belt, which usually carries the coal to a breaker, (Figure 6). This breaker reduces the size of the coal so that it will pass through 1½ in. holes in the breaker, while refuse wood, slate, iron, etc. are discharged from the end of the breaker. Coal passing through the holes in the breaker drops into a small hopper from which it may flow into a hammer mill located beneath the breaker. A feeder regulates the flow of coal to the mill. The hammer mill may be bypassed if desired.

There is considerable variation in the degree of coal pulverization through the industry, depending principally upon local conditions. In general, operators seem to favor pulverization so that 70 to 90 per cent passes through a ⅛ in. screen, particularly if several different coals are to be blended. A high degree of pulverization results in less segregation and a more intimate mixture, although it also gives lower bulk

Figure 6 — The open-end coal breaker shown here permits entry of larger pieces into the breaker. The breaker usually found in steel plants has spiders at the end of the drum.



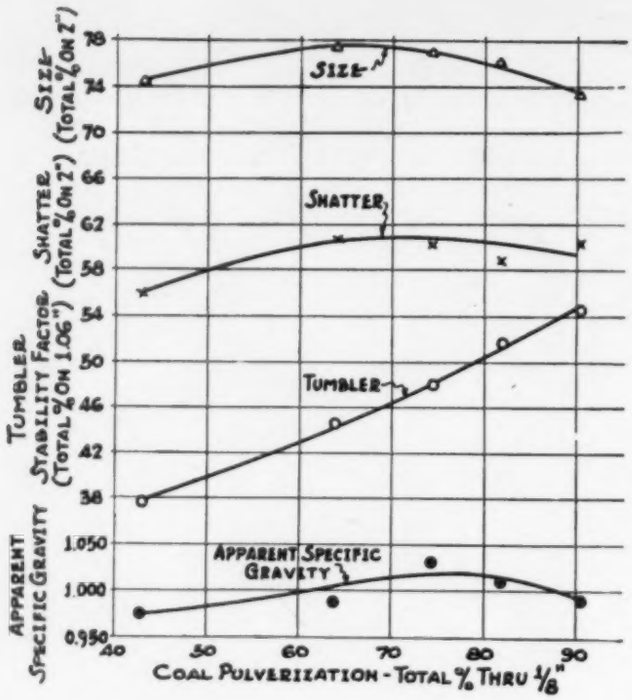


Figure 7 — Effect of degree of pulverization of coal on physical properties of resultant coke.

density, and if the mixture contains too much very fine coal, coke quality suffers. Some operators believe that fine crushing of the coal results in higher by-product yields. In some cases, where only high-volatile coals are used, and even where mixtures of coal are used, coarse coal (up to 1½ in.) is used to obtain high bulk density. The best size of pulverized coal must be determined by the individual plants for each coal blend.

Although the hammer mill crushes the soft, friable portion of the coal to a fine powder, the hard, slaty material remains comparatively coarse. These larger pieces of slaty material cause fractures in the coke, which decrease its strength and increases breakage.

From the hammer mill, a belt conveyor carries the pulverized coal to the top of the mixer building and discharges it through an adjustable chute into any one of the mixer bins. Four or more bins are desirable, although some of the older plants have only two. These bins are of steel or reinforced concrete constructions, and may be lined at least in part with hard brick. Each bin has a capacity of 200 to 400 tons. A total mixer bin capacity equal to the coal that can be handled by the coal handling equipment in 3 or 4 hours is usual.

Under each bin is a short mixer conveyor belt which delivers coal out of its respective bin on to a receiving belt. Gates at the bottom of each bin regulate the height of the coal stream from that bin, hence proportioning by volume the various coals entering the mixture to be charged. Periodic checks of the weight per unit volume of each coal then maintains a constant coal mixture. Some plants, however, have installed automatic weighing control apparatus on the mixing belts, preferring to mix by weight. Mixing should in any case be controlled to an accuracy of about one per cent.

Instead of pulverizing the coal before mixing, as described in the foregoing, some plants have the hammer mill installed in the system after the mixing bins, which although proportioning the mixture by volume may not be quite as accurate.

The blended coal is then carried by one or more belt conveyors up to the oven storage bin. Mixer paddles may be installed in the chute through which the coal enters the storage bin. A sprinkling device is usually installed over the belt conveyor so that moisture content of the coal may be increased if desired.

The oven storage bin should have a capacity adequate to supply the ovens for a period of about 24 hours. The bin is of steel or reinforced concrete construction and may be lined in part with brick. It is generally arranged in three to five bays, with each bay having one or two rows of hoppers, the number of hoppers in each row corresponding to the number of charging holes in each oven. At the bottom of each hopper is a gate, operated manually or mechanically.

The capacity of coal handling equipment should be such that the day's consumption of coal can normally be handled in about 6 hr, thus allowing starting and cleaning up in one 8 hr turn. Thus, single battery plants may install equipment that will handle 150 tons per hour, while larger plants may go to 300 to 500 tons per hour.

Belting used for coal handling ranges 30 to 48 in. in width, and may be 5, 6 or 7 ply, 28 or 32 oz. duck with perhaps $\frac{1}{32}$ in. bottom cover and $\frac{3}{16}$ in. top cover of rubber.

The belts run at speeds ranging up to 400 fpm in troughed idlers 5 to 6 in. in diameter spaced on 4 ft centers. Return idlers are spaced about 10 ft apart.

When regular daily shipments of coal cannot be depended upon, it is of course necessary to stock coal. In such cases, coal may be taken from the receiving track hoppers to a storage yard by conveyor. Some plants, particularly the larger ones, employ a car-dumper and a coal bridge to handle incoming coal.

The use of car shakeouts, wherein the entire car is subjected to a vigorous shaking action, is gradually increasing. The unit is placed over the receiving track hoppers and reduces considerably the labor required to clean out the cars.

Plants receiving coal by water shipment may use a steel coal bin of 7000 to 10,000 tons capacity at their dock so that self-unloading boats, which unload at a rate of about 1200 tons per hr, will not be delayed. Coal is then discharged from the bottom of the bin through a series of gates and conveyed on rubber belts

Figure 8 — View of self-unloader boat discharging coal into a 7000-ton receiving bin at a rate of 1200 tons per hour.

either to a storage yard at a rate of perhaps 600 tons per hr or to the coal preparation system.

At the storage yard a self-propelled stacker with a boom of 75 to 100 ft may unload coal on either side of its runway, which may be 1000 to 1500 ft long. Coal is taken from storage by tractor crane equipped with a bucket of about 4 cu yd capacity, or some other type of reclaiming device, and is placed in self-propelled hopper cars which travel on the stacker runway and which feed the coal to the conveyor leading to the coal preparation system.

A primary problem in the storage of coal is the prevention of oxidation and spontaneous combustion in the stock pile. This trouble can be minimized by careful stocking in layers of 3 to 5 ft and packing down the coal with a roller or bulldozer. Coal thus rolled may weigh 60 to 75 lb per cu ft, as compared to 53 lb per cu ft for unrolled coal. Coal piles may also be covered over with a material that will prevent free access of air.

Proper storage will also serve to improve the uniformity of coal going to the ovens. However, coke quality usually suffers if the coal used is heavily oxidized. In general, the lower the oxygen content of the fresh coal, the better it will store.

A serious problem in winter time may be the unloading of frozen coal from railroad cars. Many plants use gas or oil burners on the outside of the cars, but this procedure may seriously damage cars. Jets of live steam may be effective if suitable openings are available in the cars. A thaw shed of sufficient capacity is an effective solution, but costs are high. A less costly plan is to fence the sides of a track with sheeting and provide pipe lines, paralleling the track, with orifices at one-foot intervals to burn gas. This method is fairly satisfactory, although not as efficient as a thaw shed. Some plants have made use of machines having auger shaped drills to loosen the coal in the cars. The use of chlorides on the coal at the mine to prevent freezing is undesirable, as the chemical would attack oven brickwork and give trouble in the by-product plant. Oil (0.1 to 0.2 gal per ton of coal) applied to coal at the mine is effective in reducing freezing if the coal is larger than $\frac{3}{8}$ in.

The larry car (Figure 9), which operates on top of the battery and transports a charge of coal from the bin to each individual oven, consists of several hoppers (generally three or four) mounted in a structural frame which travels on four wheels. The car may be of high or low design, and may be driven by one central drive connected to the wheels on both sides or by two separate drives, one on each side. In either case, drive power of 30 to 35 hp is usually applied, using d-c mill motors with full magnetic, reversing, plugging control. The larry car may have a wheel base of about 17 ft and a span between rails of about 17 ft, and travels at speeds up to 250 to 300 fpm.

Hoppers are of $\frac{5}{16}$ to $\frac{3}{8}$ in. steel plate, cylindrical in shape, with conical lower section. In most of the existing larry cars, coal flows from the hoppers by gravity. Recently, the use of a mechanical feeder, such as a vibrating pan feeder, rotating feed table or screw conveyor, has been advocated. The use of a mechanical feeder gives close regulation of the rate of feed through each charging hole and thus affords some regulation of

Figure 9 — The larry car, carrying in its hoppers the exact amount of coal for one oven, is used to charge the ovens.

bulk density of the charge. Drop sleeves at the bottom of each hopper guide the coal into the charging holes. These sleeves are so interlocked that the hopper discharge cannot be opened unless the sleeves are lowered, and so that the car cannot be moved unless the sleeves are raised.

Each hopper has an adjustable measuring device for volumetric control of the charge. These devices may be set to vary the capacity of the hoppers within reasonable range. Total capacity of the hoppers must equal the cubical content to be charged into an oven.

Control of bulk density of the coal charged to the ovens has recently received considerable attention. Such control results in coke with more uniform physical characteristics, and also simplifies heating and operation of the ovens. The principal factor affecting bulk density is the surface moisture of the coal, although fineness of crushing is also important. Bulk density decreases as surface moisture increases, and as coal fineness increases. The effect of moisture content can be offset to a great extent by the addition of small amounts of oil to the coal charge. Such additions increase the bulk density of wet coal, but may reduce somewhat the bulk density of coal that has no surface moisture. Results from tests in one plant showed that the addition of one gallon of oil per ton of coal resulted in a 7 per cent increase in bulk density, and that the use of oil decreased the fluctuations in density caused by changes in moisture content of coal.

OVENS

Practically all of the by-product coke ovens now operating in the United States are of the vertical slot type. The ovens are rectangular chambers 30 to 45 ft long, 6 to 15 ft high, and 14 to 22 in. wide. The trend has been toward high ovens so as to obtain greater capacity with minimum costs of construction and operation.

The modern oven is a chamber about 40 ft long, 12 to 13½ ft high, and 16 to 19 in. average width. The 14 in. oven, with its lower coking time, is still used in a few cases where it might possibly benefit coke quality from inferior coals by reducing over-coking. The width

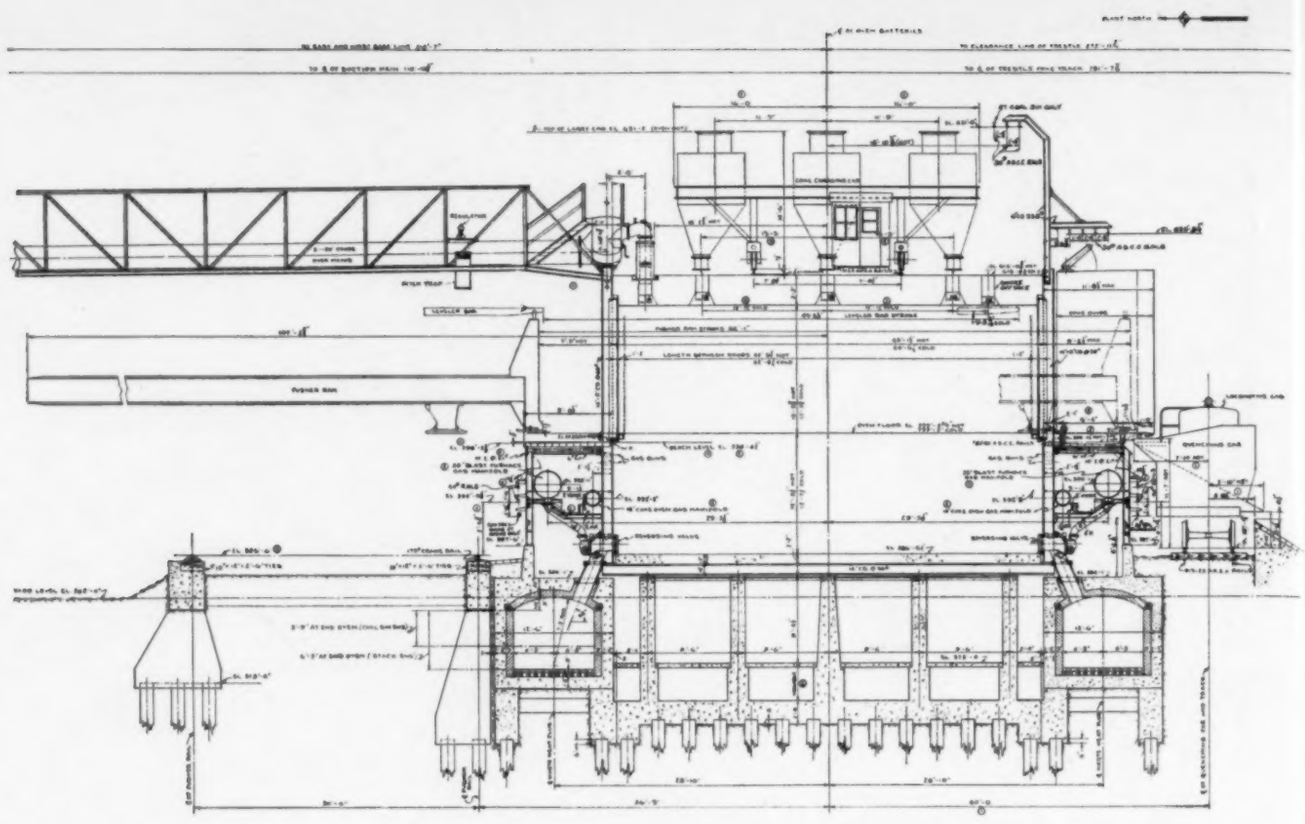


Figure 10 — Cross-section through coke-oven battery.

tapers off 2½ to 4 in. from coke side to pusher side, according to the characteristics of the coal to be coked. The greater tapers are used with coals of marked expanding tendencies.

Ovens are usually charged with coal to a level of 12 to 14 in. from the oven roof, thus filling 91 to 92 per cent of the total oven volume. Modern units therefore will hold 700 to 750 cu ft of coal, which, at a normal bulk density of 50 lb per cu ft, gives 17.5 to 18.8 net tons of coal per oven, or a coke production of 13 to 14 tons per oven.

Coking time depends on the width of the oven, temperature of oven walls, kind of coal, and the fineness and moisture content of the coal. In general, ovens are designed for a standard coking velocity of one inch per hour (coking velocity = oven width in inches ÷ coking time in hours). In practice, coking velocities of 1.2 in. per hr or higher are often used. Actually, with wall temperatures equal, a narrow oven will operate on a proportionately shorter coking time than a wide oven. For example, with equal temperatures, a 14 in. oven will operate on a coking time of about 55 per cent of that of a 20 in. oven. To coke coal in the two ovens at the same velocity, the wider oven must have a higher wall temperature.

Gross coking time is the time elapsed between two successive pushings of the same oven, while net coking time is the time of actual coking, usually amounting to about 96 per cent of the gross time.

The capacity of a coke oven may range 2.0 to 2.5 lb of coal coked per hr per sq ft of coal-covered wall area, the narrower ovens running to the higher values.

A modern oven, under normal operations, will produce about 0.75 tons of coke per hr.

In the roof of each oven are three or four charging holes 14 to 16 in. in diameter spaced along the length of the oven and extending up through the brickwork to the top of the battery, where they are closed with a cast iron frame and cover. The oven roof also carries, either at one or both ends, an offtake about 14 in. in diameter which leads to the ascension pipe, which in turn connects into the collecting main. The ascension pipes (12 to 14 in. in diameter inside of their refractory lining) may be of steel or cast iron construction, and are provided with a covered opening for bleeding, a steaming connection, inspection plugs, and a liquor flushing spray.

The oven top above the oven roof may range 3½ to 4½ ft in thickness.

The ends of the ovens are closed by refractory lined doors of welded steel and cast iron construction. In the older plants, these doors and the door frames were designed with a recess so that they could be luted with clay to make a tight closure. More recently, self-sealing doors have been adopted, wherein a flexible steel plate or diaphragm carrying a sealing edge is incorporated into the door so that it will conform to irregularities in contour of the door jambs (Figure 11). The door is held in place by latch bars. Each door must have guides and hooks for lifting it, and the doors on the pusher side must have a leveler door to permit entry of the leveling bar. Cast iron door jambs, with machined contact surfaces, ensure a tight fitting door. These jambs are mortared into the brickwork and fastened to the buck-

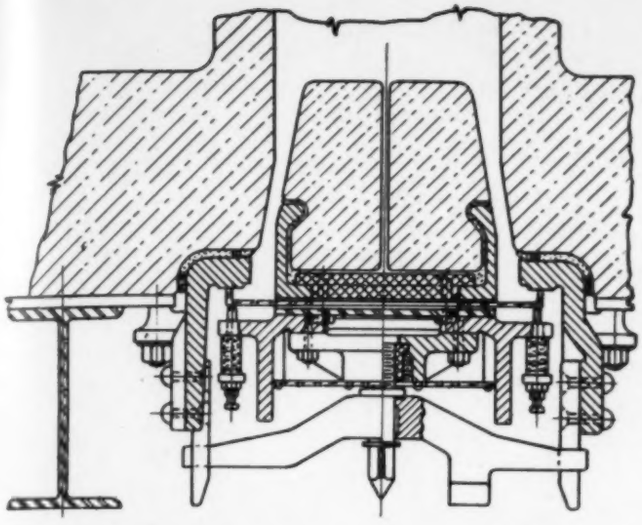


Figure 11 — Self-sealing doors, using a knife-edge on a flexible plate to effect closure, have eliminated the necessity of luting in modern installations.

stays or to steel flash plates which may be used to protect the face of the brickwork. Asbestos packing is used to prevent leakage.

Ovens are grouped side by side, on centers of 3½ to 4 ft, into a battery which may contain as many as 87 ovens. In each wall between adjacent ovens are perhaps 28 or 29 vertical heating flues on centers of 15 to 18 in. These flues are approximately 10 in. × 16 in. in cross section and extend almost the entire height of the oven chamber. The walls separating the oven chamber from the heating flues are 4 to 6 in. thick, with tongue-and-groove joints to prevent leakage. Thus, each row of flues serves to heat two adjacent ovens except at each end of the battery. An inspection hole is provided in the top of the battery for each vertical flue, so that heat distribution may be observed.

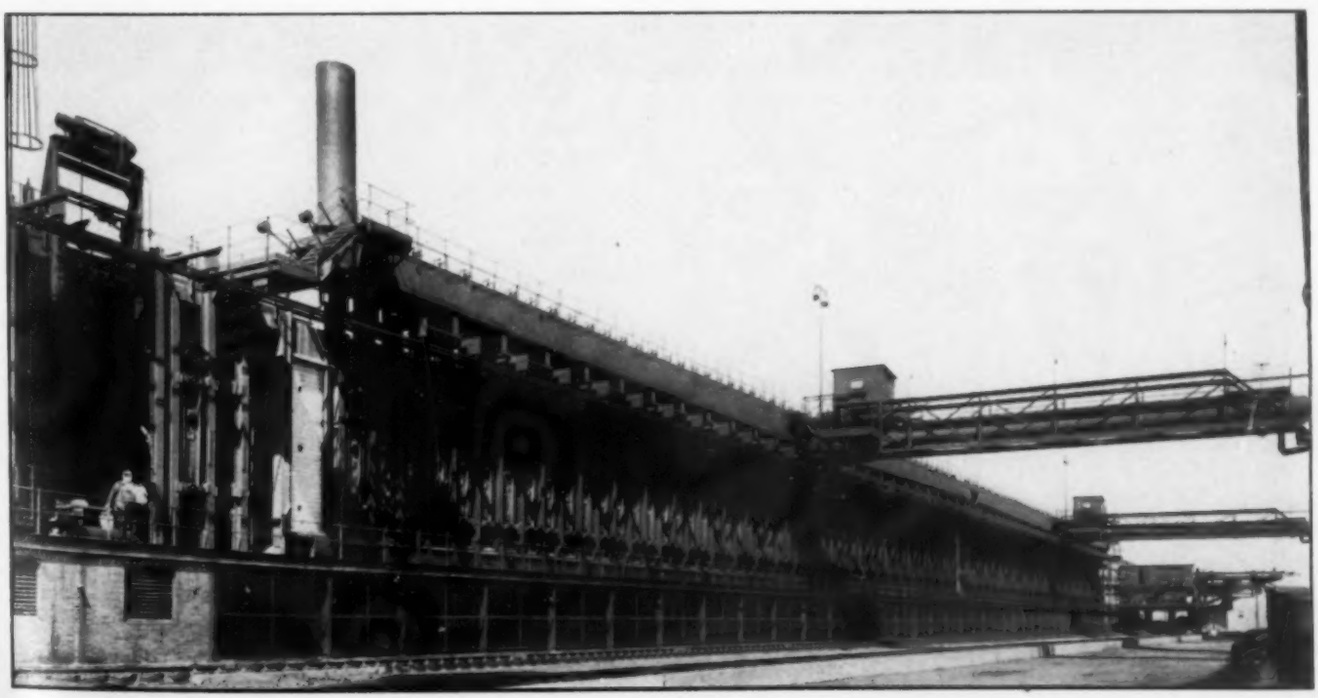
Beneath the oven chambers and heating flues are regenerator chambers containing checker work which reclaims heat from the outgoing waste gases, and, upon reversal, gives up heat to the incoming combustion air. If a lean fuel gas (blast furnace or producer gas) is used to heat the ovens, it is also preheated in the regenerators, in order to obtain the necessary flame temperatures for rapid schedules. In such cases, the regenerative system must be designed to permit preheating both air and gas. The checkerwork is usually made up of slotted fire clay shapes, with ⅝ to 1½ in. flues and walls of ⅝ to 1 in. thickness. These shapes are piled to a height of 5 to 6 ft. For each oven the checkerwork provides 10,000 to 11,000 sq ft of heating surface and perhaps 35,000 to 50,000 lb of effective regenerative material.

The arrangement of oven heating flues and regenerators, and the path of gas flow through them varies somewhat in the designs of the various builders. Although there are a few by-product ovens of several other designs, four basic designs comprise about 97 per cent of the total coking capacity in the country: Koppers, Koppers-Becker, Wilputte and Semet-Solvay.

The Koppers oven (Figure 13) is a double-divided design, wherein all vertical heating flues in each wall connect at the top into a single horizontal flue. The regenerator chambers beneath the ovens are divided into halves. The ovens are heated by burning gas in the vertical flues, the gases flowing upward in the flues in one-half of the oven wall, through the horizontal flue, and down through the vertical flues in the other end of the wall. This flow is reversed regularly.

In the Koppers-Becker design (Figure 13), the gases from four to six vertical flues are gathered into a short

Figure 12 — General view of a modern coke-oven battery.



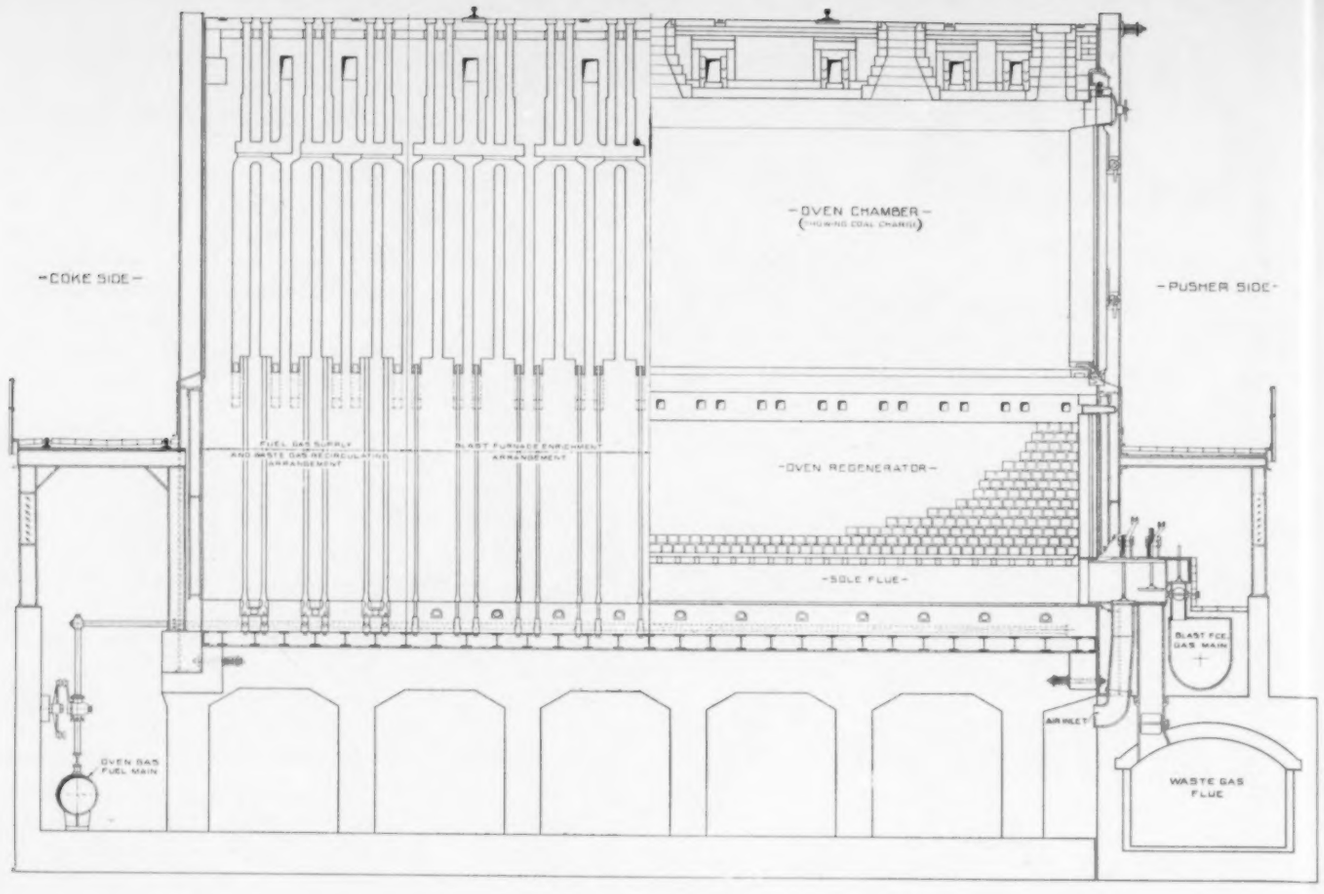
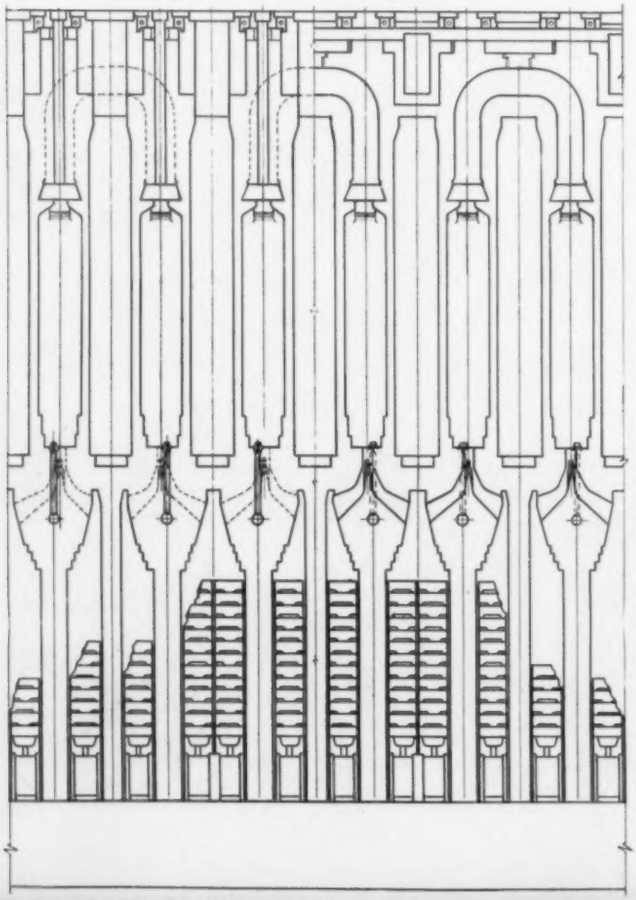


Figure 13 — Cross-section through oven battery of Koppers-Becker under-jet type. The section shows the different arrangements used for heating with enriched blast furnace gas and for heating with rich gas.

Figure 14 — This section shows the inverted U-shaped flue used in the Koppers-Becker design to conduct gases between heating flues on opposite sides of the oven. This drawing shows the gun-flue type of oven.



horizontal flue and led through a cross-over flue (Figure 14) of inverted U-shape over the top of every other oven and down through four to six vertical flues on the other side. Thus, each set of four to six vertical flues is separated from each other set. There may be five to eight of these sets across the length of the oven. This flow is reversed regularly.

The Wilputte oven (Figure 16) is a "four-divided" design. It uses the same flow principles as the Koppers design, except that the horizontal flue is divided in half, so that there are four zones instead of two. Gas flows in the two outer zones in the same direction, with opposite flow in the two inner zones. The flows are periodically reversed.

Most of the Semet-Solvay installations have oven batteries employing horizontal heating flues, wherein gas is introduced at one end and waste gas drawn off at the other end, with regular reversal of flow. Several batteries, however, have been constructed with vertical flues. These are four-divided designs, but differ from up-flow zones and the two down-flow zones are placed alternately across the length of the oven wall.

The ovens are built upon a reinforced concrete slab or mat. In older installations, this slab rests directly upon the ground, but in the newer under-jet design, the slab is supported on heavy beams and columns, forming a basement beneath the entire battery.

The oven floor may be 10 or 11 ft above the top of the oven mat, while the top of the battery may be 26 to 27 ft above the mat.

In general, all parts of oven brickwork which are

exposed to high temperatures are of high quality silica brick in special or standard shapes as may be required by the design. Secondary portions of brickwork are constructed of high grade fire clay brick, while second or third quality fire clay brick may be used as fill where temperatures are low. The top of the oven battery is covered with a layer of hard burned paving brick.

The oven battery is bound together by buckstays (approximately 14 × 8 in. wide-flange beams, 58 lb per ft) between the oven doors on both pusher and coke sides. The bottoms of these buckstays may be bolted to the beams supporting the oven slab, or they may be tied together by tie rods embedded in the slab, while cross tie rods run across the top of the battery to connect the tops of the buckstays. Additional buckstays may be placed between the main buckstays in the lower or regenerator section of the battery. At each end of the battery is a grid work of heavy beams and channels supported by a massive pinion wall. Seven or eight longitudinal tie rods extend the full length of the top of the battery to connect these pinion walls. Springs are introduced at the ends of longitudinal and cross tie rods to take up expansion and contraction of the rods.

Extending the full length of the battery on each side is a brick-paved platform, 8 to 9 ft wide, supported on structural steel work. On the pusher side the platform is merely a walkway and working platform, but on the coke side, it also serves as a runway for the door machine and coke guide.

OVEN HEATING

The ovens are heated by burning fuel gas in the vertical heating flues previously mentioned. In plants where the oven mat sits directly upon the ground, the gas used for heating the ovens is distributed to the flues by silica brick ducts or "gun brick" passing under the vertical heating flues in each oven wall. Gas is admitted to each vertical heating flue through a brick nozzle. Gas is proportioned to each flue by varying the area of the port in this nozzle.

In batteries of the elevated or underjet type, gas is distributed through steel pipes installed in the basement afforded by the design. In the pipe to each flue, a regulating orifice is installed, and gas is proportioned to each flue by changing the size of this orifice. The underjet design offers more accurate control of heating, with greater ease of regulation, because the gas is metered to each vertical flue at constant temperature and pressure, while in the old style gas duct the temperature and pressure vary widely from end to end.

Fuel gas is distributed to the ovens through mains and manifolds suitable for the fuel used. Coke oven gas is usually brought through one or two 18 to 24 in. mains that run the entire length of the battery. Two mains, one on each side of the battery, are used for the gun-brick type of distribution, while one main serves for the underjet type, feeding into 3 to 4 in. leads which run across the battery under each flue wall and feed ¾ in. risers to each heating flue. A reversing cock and a regulating device is installed in the lead for each oven. With blast furnace gas, the main may start at 36 to 40 in. in diameter and be stepped down to 24 to 30 in. A 6 in. connection may be used to feed the bus flue of each

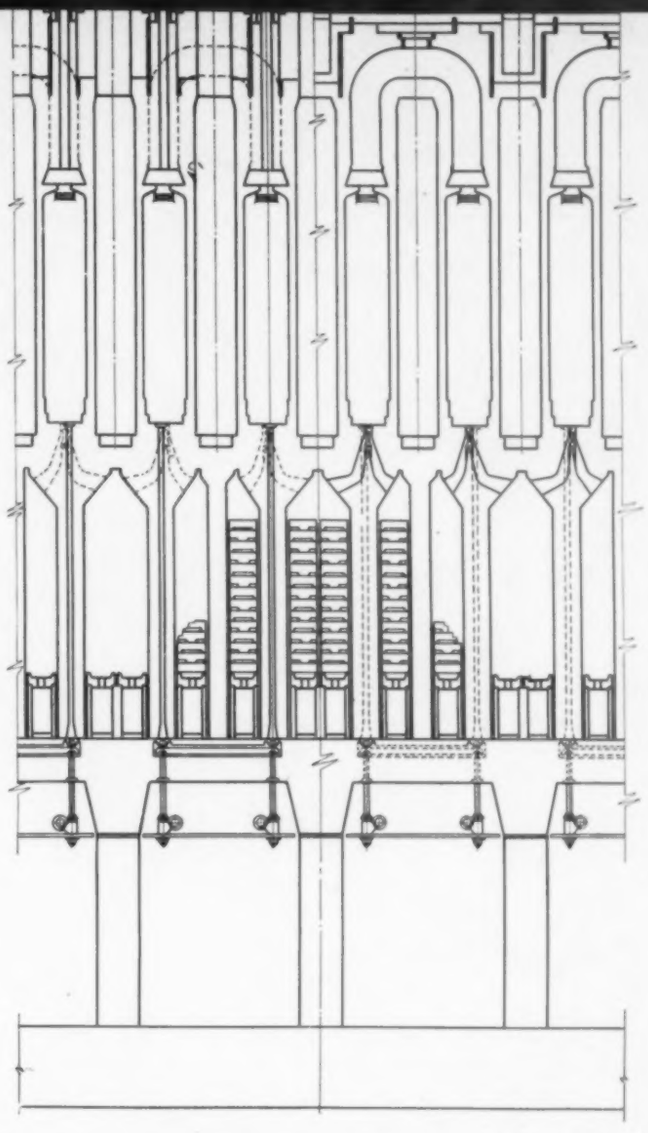


Figure 15 — This section shown is of the same basic design as Figure 14, but shows the under-jet type of oven, in which the entire battery is raised above ground level.

oven, from where the gas flows up through the regenerators and into the flues.

The reversing cocks installed on the fuel gas lines and the valves on the waste heat exits and air inlets are all operated as a unit. The valve operating levers are attached to reversing rods which run the length of the battery and are operated automatically by a reversing machine. This unit is motor driven and controlled by a timing device. An auxiliary air motor may also be installed to operate the machine in case of power failure. In normal operating schedules, the ovens are generally reversed every half hour.

Regulation of oven heating is of utmost importance, and requires co-ordination of three elements: gas supply, draft, and air supply. Gas pressure is regulated by automatic control, and the gas is now often heated by steam coils to give uniform temperature before it enters the distributing headers, thus avoiding condensation within the distribution system. Orifices provide further means of regulating gas flow to each oven and to each heating flue. Battery draft is regulated by a stack damper operating under automatic control. In addition,

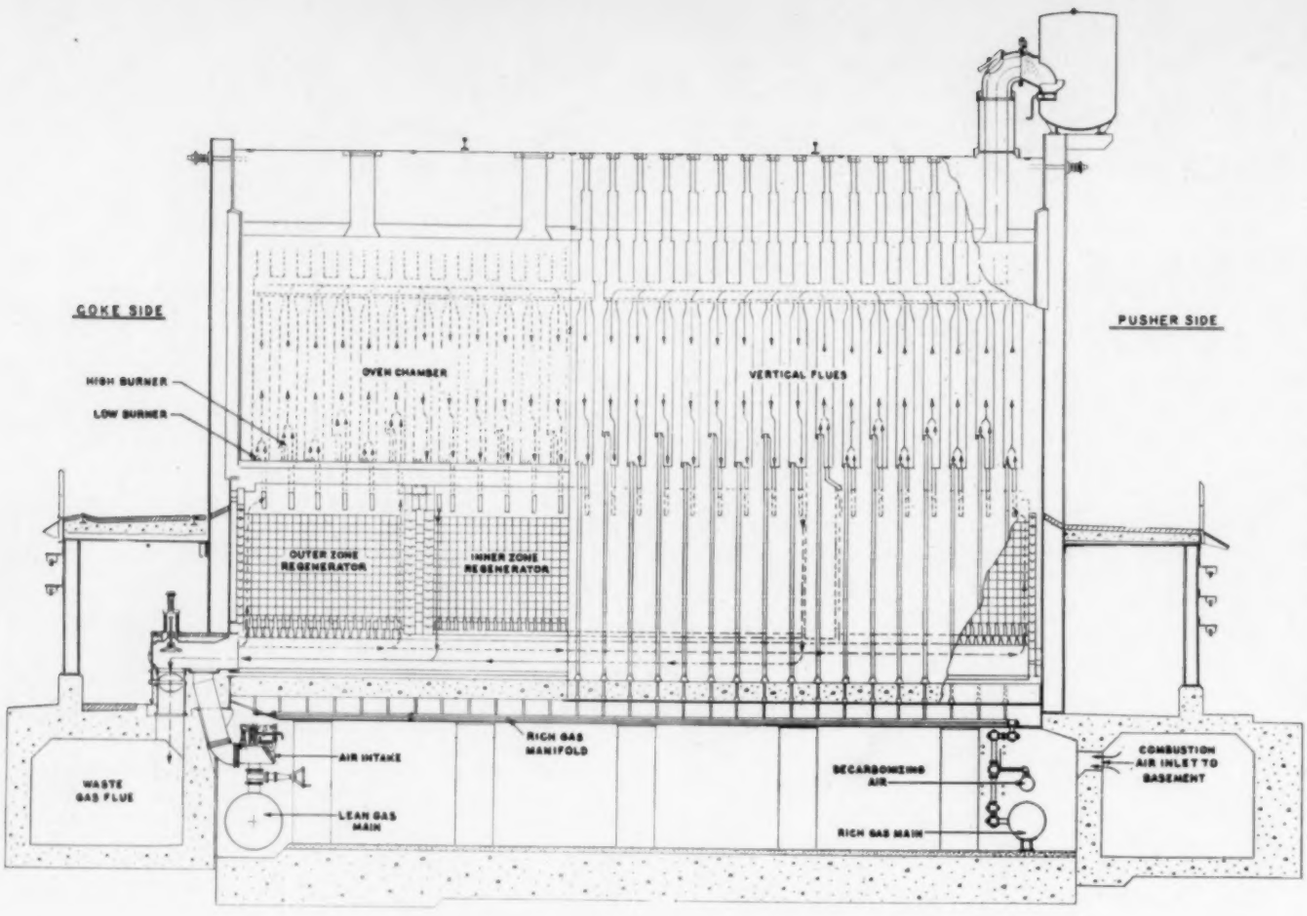


Figure 16 — Longitudinal section through a Wilputte oven showing regenerators, oven chamber and vertical flues. The pusher side is to the right.

each oven (and in some cases, each flue) is provided with an individual damper. Air flow is usually controlled individually for each oven by finger bars or damper.

The following points are to be observed for efficiency in heating:

1. Regulation of fuel gas and air to obtain complete combustion with a minimum of excess air.
2. Regulation of stack draft at a minimum so as to avoid drawing oven gases through the walls into the heating flues.
3. Gas inlet nozzles should be kept clean.
4. Oven pressure should be regulated so as to avoid pulling flue gases through the walls into the ovens.
5. Heat distribution throughout the oven should be such that coking proceeds evenly in all parts of the oven. This requires proper regulation of heating to individual flues and ovens, as well as the elimination of leakage through brickwork. Due to the taper of the oven, each foot of oven length from pusher side to coke side contains progressively more coal than the preceding foot, and consequently requires more heat input if even coking is to be obtained. Also, both ends of the oven require a greater input because of heat losses through doors.
6. Time between pushing and charging each oven must be a minimum. A regular pushing schedule should be adhered to. Some pushing schedules allow for periodic idle time on each oven so as to permit effective removal of carbon from walls, roof and standpipes. Regularity in the quantity of coal charged is essential.

With full battery operation, 2,000,000 to 2,500,000 Btu are required to heat the ovens per ton of coal coked. This means 3900 to 4900 cu ft of coke oven gas per ton of coal, or 37 to 48 per cent of the total gas produced. With decreased operations and longer coking time, the proportion of gas required for heating gradually increases until there is no surplus. The curve in Figure 20, taken from actual practice, illustrates this.

Although most of the ovens in the United States are heated with coke oven gas, some blast furnace gas, producer gas, water gas and refinery gas are also used. In the integrated steel plant, well cleaned blast furnace gas is well adapted to heating ovens designed for gas regeneration, thus releasing additional coke oven gas for other heating operations in the steel plant. Blast furnace gas for oven heating should be cleaned to a dust content not exceeding 0.005 grains per cu ft.

Lean heating gas tends to produce a more even heat in the combustion flues than do richer gases. However, blast furnace gas varies widely in quality and at times presents ignition difficulties. Also, if the blast furnace gas drops below a calorific value of 95 Btu per cu ft, oven production will fall below rated capacity. To overcome these difficulties, blast furnace fuel gas may be enriched by the addition of some coke oven gas.

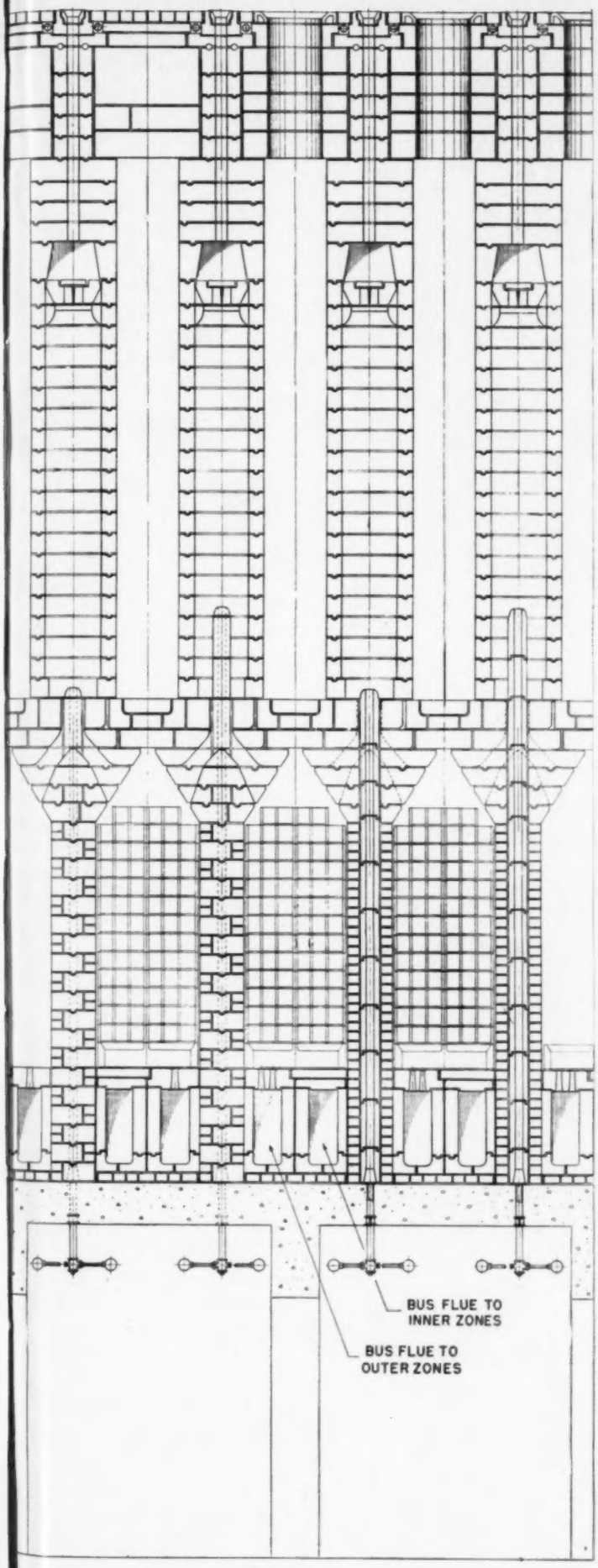


Figure 17 (left) — Section shows details of heating flues for a Wilputte installation of under-jet type. Note different levels of fuel gas nozzles.

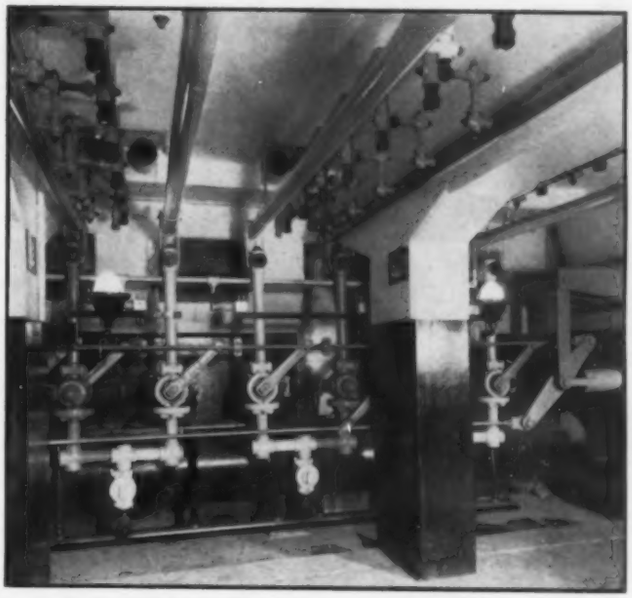


Figure 18 — Basement of under-jet battery, showing distribution system of coke-oven gas. All gas flow is reversed simultaneously through action of rods operated by the reversing machine.

Figure 19 — Blast-furnace gas main and valves in basement of under-jet battery. View shows covers open. Air intake ports may be seen next to valves.

Figure 20 — As the operation rate is decreased, the amount of surplus coke-oven gas is decreased.

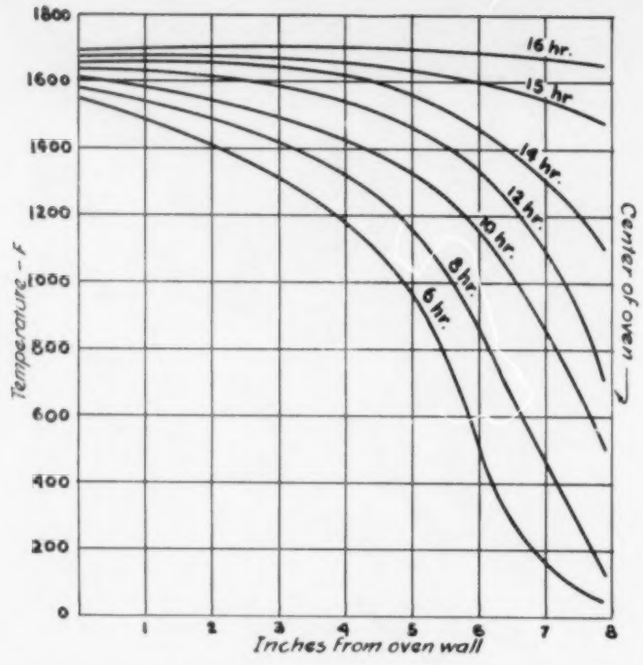


Figure 21 — Temperature distribution in the coal charge at various stages of the coking cycle are shown by this family of curves.

In some cases, the two gases are mixed so as to give a calorific value of 100 to 150 Btu per cu ft. The addition of coke oven gas must be limited when the gas is put through the regenerators. Otherwise, methane in the coke gas is cracked, reducing heating value and forming carbon deposits. An increase of about 15 Btu per cu ft in the mixed gas is perhaps the maximum enrichment when the gas is to be preheated. Many recent plants, however, are designed so that the enriching gas may be introduced directly into the heating flues, with independent regulation for each flue.

The trend toward larger ovens, with their greater capacities, introduced some heating problems which have led to changes in the heating system. The two major problems were the handling of the greater volume of gases needed for heating without too great a differential pressure, and the proper distribution of heat (particularly with rich heating gas) so as to coke the coal uniformly. The first problem has resulted in the division of the heating system into smaller units; the second has been solved by dilution of the rich heating gas with waste gas to give greater flame length, or by the use of high and low burners in alternate combustion flues. The recirculation of waste gases is effected by cross connecting vertical fuel gas risers so that the fuel gas, passing through an injector nozzle and aspirator throat, draws some waste gas from the exit side over into the stream of incoming fuel gas.

With high and low burners, the burners in alternate heating flues are placed 12 to 27 in. above the level of the oven floor, while in the intervening flues, the burners are 6 in. above oven floor level. This arrangement tends to distribute vertically the high temperature zone of initial combustion when heating with rich gas.

New ovens must be carefully dried and heated to avoid uneven expansion and cracking. Fire (wood or gas) is first placed in the coking chambers, and the temperature is brought up to about 250 F over a period of two weeks or more, the fires being vented into the combustion chambers through temporary holes in the oven walls. Coal or gas fires are then used, and the temperature is raised about 25 F per day for four to five weeks, after which the temperature can be brought up nearly to operating range. At this point, three or four days before charging, the gas is turned into the normal fuel gas heating system. Tie-rods and expansion joints must be carefully watched during the drying and heating process.

When ovens are heated with coke oven gas, there is a tendency for carbon to form in under-jet gas risers, gun flues, nozzles and gas channels. This carbon is removed by passing air through these ducts during their off-gas period or during the reversal period. Air is supplied by natural draft or by a fan which runs continuously. When a fan is used, an 8 to 12 in. air duct runs the entire length of the battery, with 1½ in. branches leading to each reversing cock or to each gas flue. Ovens in which waste gases are recirculated seem to be relatively free of this carbon deposition, and decarbonizing apparatus is not normally installed with ovens of this design.

Waste gases leaving the regenerators pass through one or two waste heat flues of about 50 sq ft cross section which run along one or both sides of the battery and are connected to the oven chimney. In some cases two connections are used so as to provide better balanced draft.

The oven chimney may be 225 to 275 ft high and 8 to 12 ft inside diameter at the top. It is usually constructed of radial brick. Automatically controlled regulating dampers in the flues leading to the stack maintain a constant draft upon the oven heating system.

Temperatures prevailing around an oven battery are approximately as follows:

	Degrees F
Preheated air	1500-2100
Flame	2800
Oven flue	2200-2750
Oven wall	1900-2300
Oven top	1400-1500
Coke	1800-2000
Gas leaving oven	1100-1300
Gas entering collecting main	550- 750
Gas entering suction main	75- 275
Liquor in collecting main	175 or less
Oven stack	550- 650

Temperatures at different points in the coal charge

TABLE V

DISTRIBUTION OF HEAT SUPPLIED TO OVENS

	Btu per lb of coal	Per cent
Sensible heat in dry flue gas	154	12
Sensible and latent heat in water vapor in flue gas	167	13
Sensible heat in coke	473	37
Sensible heat in coke gas	167	13
Sensible and latent heat in tar and water vapor in coke gas	154	12
Radiation and unaccounted for	167	13
Total, gross btu supplied	1,282	100

with a 16-hr coking time are somewhat as given in Figure 21.

The distribution of heat supplied to the ovens averages about as shown in Table V.

Table VI gives a complete total *heat balance*, which is calculated as follows:

Input:

1. Gross heating value of 1 lb of coal as charged.
2. Sensible heat in coal is so slight as to be negligible.
3. Latent heat of fuel gas = cu ft supplied per lb of coal × its gross calorific value per cu ft.
4. Sensible heat in fuel gas = cu ft supplied per lb of coal × temperature of gas, degrees F, × volumetric heat content (approximately 0.0194 × 0.0000047 t, degrees F for coke oven gas).

Output (Equals input):

5. Gross heat value of coke produced from 1 lb of coal.
6. Sensible heat in coke = lb of coke produced from 1 lb of coal × coke temperature × mean specific heat (approximately 0.36).
7. Latent heat in gas = cu ft of gas from 1 lb of coal × gross heating value per cu ft.
8. Sensible heat in gas = cu ft of gas from 1 lb of coal × outlet gas temperature × specific heat (as in item 4).
9. Heat content of water vapor in gas = lb of moisture carried by gas from 1 lb of coal × (1090.7 + 0.46 × outlet gas temperature).
10. Latent heat in tar = lb of tar from 1 lb of coal × gross heating value per lb (approximately 16,500 Btu per lb).
11. Sensible heat in tar = lb of tar from 1 lb of coal × temperature, degrees F, × specific heat (approximately 0.5).
12. Latent heat in light oils = gal produced from 1 lb of coal × gross heating value (approximately 150,000 Btu per gal).
13. Total stack loss = lb of waste gas per lb of coal coked × stack temperature × mean specific heat (approximately 0.24) + lb of moisture in stack gas × (1090.7 + 0.46 × stack temperature, degrees F).
14. Radiation, etc., is found by difference. The loss through walls, etc., has been estimated at an average of 195,000 to 200,000 Btu per oven per hour. A break-down of this loss is somewhat as follows:

Area	Heat loss, Btu per sq ft per hr
Doors and frames	600- 900
Charging lids and frames	2500-4000
Oven tops	150- 300
Tops of heating flues	280- 590
Leveling door	800-1500
Gas collection piping	150- 225
Regenerator walls	100- 200
Lower oven structure	60- 80
Regenerator bottoms	130- 160

The foregoing heat balance gives no consideration to reactions occurring during the coking stage of the process. These are generally recognized as exothermic. The omission of this item on the input side will have the effect of decreasing the output item of radiation and unaccounted-for loss. It is also apparent that the first stage of the process, including driving off of hydroscopic water and raising coal temperature to its fusion point (about 780 degrees F), requires much more external heat than the subsequent coking stage.

An important factor in coke oven operation is the cycle of charging and pushing the ovens. It is generally agreed that the adjacent ovens on both sides of the oven being pushed should be as close as possible to the same age or degree of coking. To this end, various pushing schedules have been devised. In these schedules, the ovens of a battery (or in some cases, two or three batteries) are divided into a number of groups, each group usually consisting of 5, 7, or 9 consecutive ovens. The number of such groups in a battery is, of course, the total number of ovens divided by the number in each group.

Pushing then proceeds on the first oven in each group,

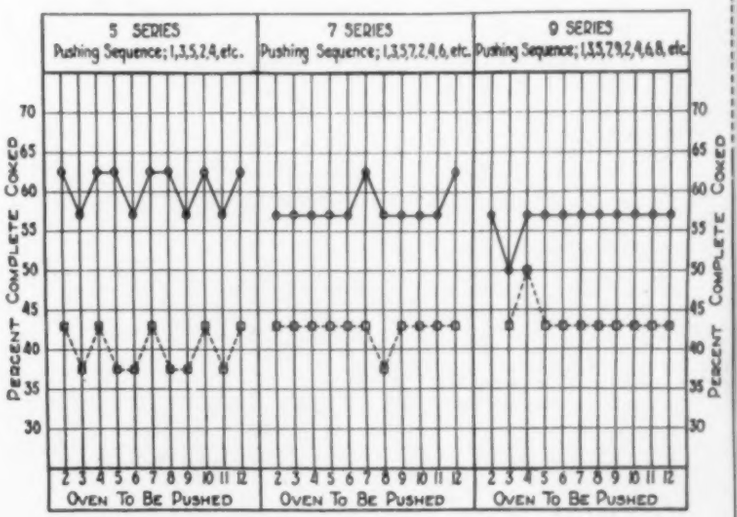
TABLE VI

TOTAL HEAT BALANCE TO COKE OVENS

Input	Btu per lb of coal	Per cent
1. Latent	13,500	91.17
2. Sensible heat in coal	12	0.08
3. Latent heat in fuel gas	1,270	8.67
4. Sensible heat in fuel gas	12	0.08
Total	14,794	100.00

Output	Btu per lb of coal	Per cent
5. Latent heat in coke	9,563	64.62
6. Sensible heat in coke	520	3.52
7. Latent heat in gas	3,045	20.60
8. Sensible heat in gas	191	1.29
9. Heat content of water vapor in gas	129	0.87
10. Latent heat of tar	598	4.04
11. Sensible heat of tar	6	0.04
12. Latent heat of light oils	132	0.89
13. Heat content in stack gas	440	2.98
14. Radiation and unaccounted for	170	1.15
Total	14,794	100.00

Figure 22 — This chart shows the age of adjacent ovens when pushing on three different schedules. Circles denote right hand adjacent oven, squares denote left hand adjacent oven.



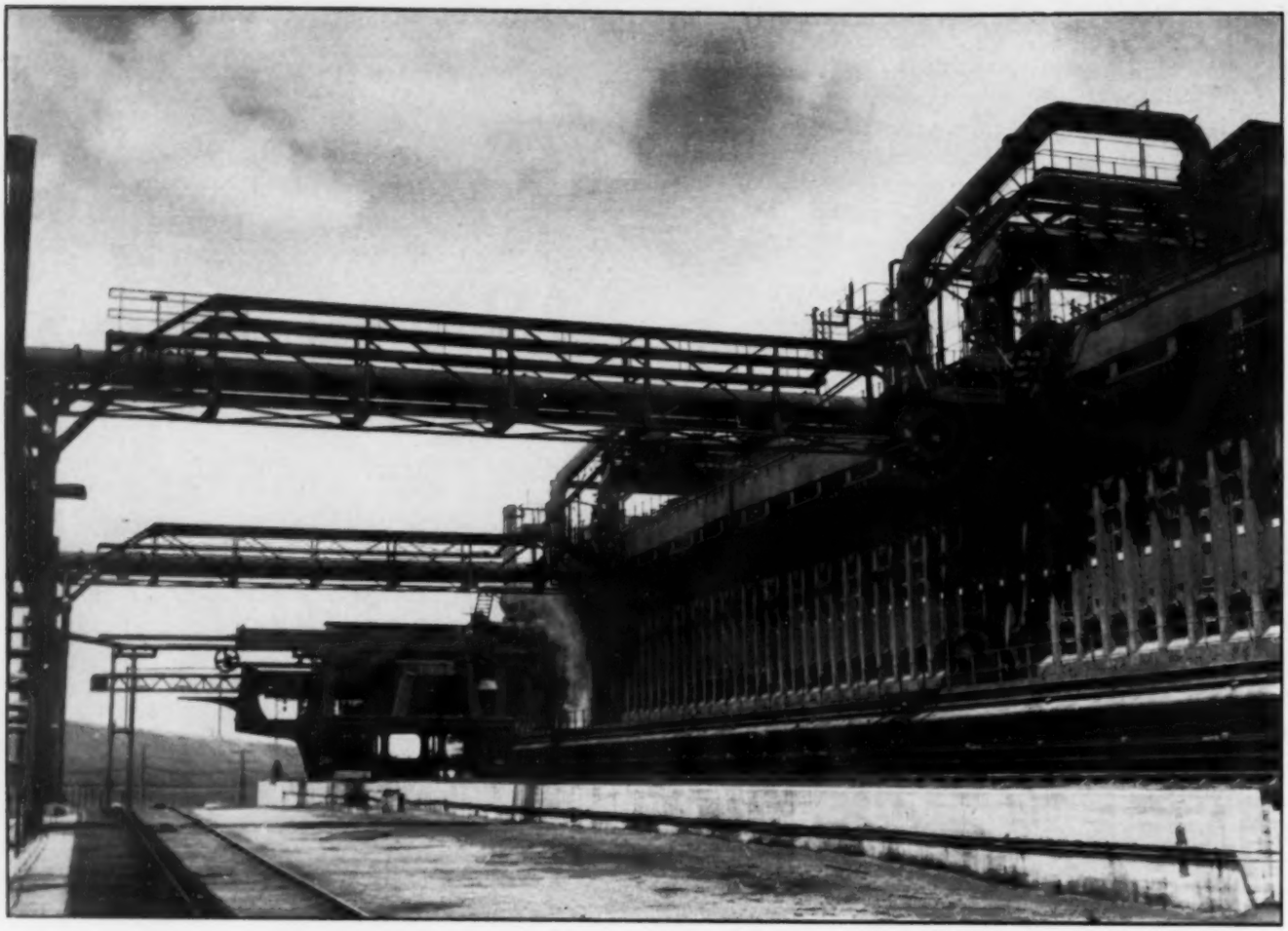


Figure 23 — General view of pusher side of coke battery.

then on the third in each group, then the fifth, and on through the odd numbers. When the odd numbers have been covered, the second oven in each group is pushed, followed by the ensuing even numbers. These sequences are set forth in Figure 22, which also shows the relative age of the adjacent ovens. In these examples, the 9-series shows the smallest difference in age of adjacent ovens, and this series is probably in widest use.

A number of other pushing schedules are in use, some of which become rather complicated. Some schedules have been patented. Several schedules include a short idle period for each oven after pushing to permit decarbonizing of oven walls. This is particularly important with coals of high volatile content.

COKE HANDLING

The pusher machine is formed of heavy structural shapes and plate, welded or riveted construction. It may have a wheel base of 18 to 23 ft and a rail span of 28 to 30 ft. This machine functions to level the coal in each freshly charged oven, to remove the oven door on the pusher side of the battery when coking is completed, to push the finished coke from the oven, and to replace the door after pushing. Machine traction is generally provided by a d-c mill motor of 46 to 65 hp. Machine speed may range from 275 to 400 fpm.

The leveler bar is usually constructed of side plates tied together to form a member about 10 in. square. It carries a scraper and pulling clip, and may be driven by rope and drum or by pin and sprocket at speeds of 90 to 120 fpm. A d-c motor of 15 to 35 hp is usually used. The bar may be withdrawn manually if power should fail while the bar is in the oven. Coal withdrawn from an oven by the leveler bar is caught in a small hopper. This hopper may be discharged by a conveyor on to the top of the leveler bar, which then carries the coal into the next oven, or the hopper may be dumped into an elevator which returns the coal to the oven bin.

The pusher ram, which in the modern plant is 70 to 75 ft long with a stroke of about 60 ft, may consist of an I-beam section about 30 in. high, driven by rack and pinion, or the ram may be of lattice or open construction. The ram head is of cast steel, and must withstand high temperature and abrasion.

A motor of about 65 hp is usually used to drive the ram at speeds of 50 to 60 fpm. Movement of the ram is automatically controlled so that the ram travels across the space from machine to oven, slows down as it comes to the face of the coke, and then accelerates to push through the oven. At the end of the stroke, the

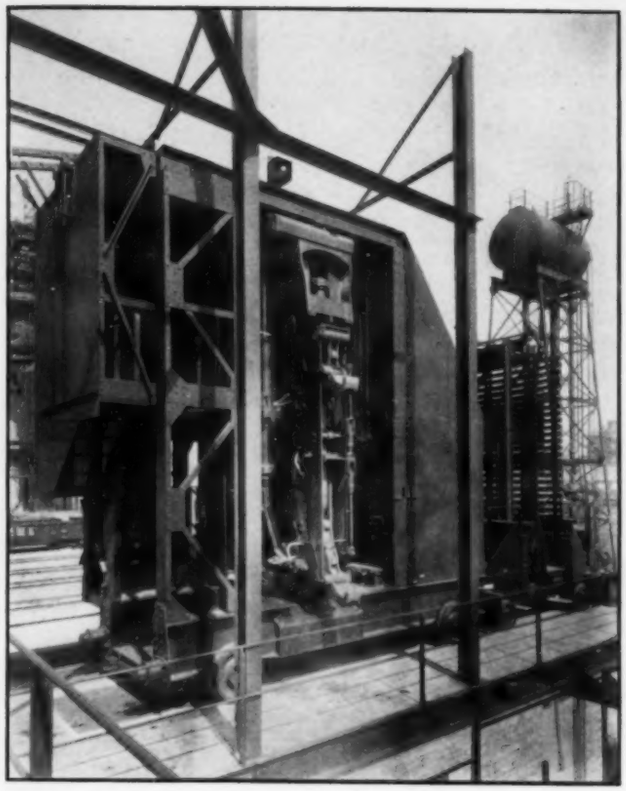


Figure 24 — Coke-side door machine, showing hooks which engage and remove oven doors. The extractor mechanism shown here is hydraulically operated.

ram slows down, reverses, and withdraws at a higher speed from the oven. Air or steam power is supplied to finish pushing an oven and then withdraw the ram in the event of power failure.

A carbon blower is attached to the top of the ram head to remove carbon which may be deposited on the roof of the oven. Air is supplied to this blower from a 100 cfm, 100 psi compressor carried on the pusher machine. Carbon cutters, mounted on the pusher ram head, may be used to remove carbon from oven roofs.

Also mounted on the pusher machine is a door extractor which is largely a duplicate of the independent coke-side door machine.

On the coke side of the oven is a door machine (Figure 24) which travels along the coke bench. This machine consists of a motor-driven underframe carrying operating devices for unlatching, removing and swinging the door to one side. The machine may have a wheel base of 11 to 12 ft and a rail span of between 5 and 6 ft. A motor of 10 to 15 hp drives the machine at speed of 250 to 300 fpm. The door extractor mechanism may be driven, through rack and pinion or crank and rod, by electric motors or by hydraulic cylinders. In the latter case a small 1000 psi hydraulic system is carried on the door machine.

Coupled to the door machine is the coke guide, a cage-like affair of flat bars about two feet wide and extending the height of the oven. When the guide is opposite the open end of the oven, it is moved close to the face of the oven, thus reducing spillage to a minimum.

The quenching car, which receives the coke pushed from the oven and transports it to the quenching station, is a standard gage car of special design. The car bottom slopes to discharge coke onto the coke wharf by gravity with minimum breakage. A slope of 28 degrees is common.

Modern quenching cars are about 40 ft long and 12 or 13 ft wide. They are built of cast iron or hard steel plate on a structural steel frame. Their construction must be such as to resist abrasion, the high temperatures of the hot coke, and the shock of sudden cooling during quenching. The design must be such that water will drain out rapidly and completely. Discharge gates are operated by double-acting pneumatic cylinders or by electric motors.

The quenching car is moved by a standard gage electric locomotive, usually of 20 ton rating, and capable of producing 10,000 to 13,000 lb drawbar pull.

A quenching station may handle the output from as many as 150 ovens. This station is about 20 ft × 50 ft, and 50 to 100 ft high, with arches at each end and through which the quenching car and its locomotive can pass. See Figure 26. This unit is generally built of brick and lined with salt glazed vitrified brick, although some have a structural steel framework with corrugated transite siding attached to the inside of the framework. A tank of 10,000 to 12,000 gal capacity may be installed in the top of the station, approximately 40 to 50 ft above yard grade, feeding through a 12 to 16 in.

Figure 25 — Coke pushed from the oven passes through this cage-like coke guide and falls into the quenching car.

Figure 26 — In the quenching station, the quenching car full of hot coke is cooled rapidly by heavy sprays of water.

header and 6 in. spray pipes to sprays located over the quenching car so as to give an oven distribution of water over the hot coke in the car.

The control valve to release the quenching water is electrically operated from the cab of the locomotive, and water is sprayed on the coke at a rate of 6000 to 10,000 gpm for a period of 40 to 60 sec. Care must be exercised to insure proper quenching. Coke must be loaded evenly in the quenching car. Insufficient quenching will result in insufficiently cooled coke, while overquenching will leave too much moisture in the coke. An automatic timer for the operation of the water control valve is recommended.

Of the water used for quenching, 15 to 20 per cent is evaporated. The remainder runs from the car and drains into a concrete sump, where it passes over baffles and through screens to remove fine coke particles. The water is then pumped back into the overhead tank. Pumps for this service, rated at 500 to 1500 gpm, are controlled by a float in the overhead tank. In some plants, the quenching station is supplied with waste water from by-product cooling equipment and the water is not recirculated. When there is sufficient waste water, quenching may be direct from pump to sprays, without a tank. In such cases, a pump of 8000 to 10,000 gpm capacity is used, with a duplicate pump as a spare.

After quenching is completed, the quenching car is moved back to the coke wharf, where the coke is discharged. The coke wharf is usually of such length as to hold approximately one hour's production of coke, allowing 30 to 40 ft of length per oven-load. The inclined wharf is lined with hard brick or with cast iron wearing plates. The flow of coke from the wharf to the wharf conveyor belt is controlled by means of gates operated from a walkway extending the length of the wharf. Any hot coke on the wharf may be spot quenched by the operator before the coke is dropped onto the wharf belt for transport to the screening station.

The screening station is a combination of single and double-deck screens, conveyors, chutes, by-passes, crushers and hoppers, flexibly designed so that coke can be produced in any desired size by the use of various combinations of screens. Coke from the ovens may first pass over a vibrating scalping screen, 5 to 6 ft wide × 12 to 14 ft long, with openings of about 4 in. Coke passing over this screen may be loaded into cars for foundry use, or it may be put through adjustable roll crusher and reduced to 4 in. and under. This crusher is usually a two-roll unit with special iron segmental toothed rolls about 32 in. in diameter × 36 in. face. One roll is usually adjustable so that the degree of crushing may be varied as desired. The coke which passed through the first screen and the coke leaving the crusher is then passed over a second vibrating screen with openings of 2 to 2½ in. Coke passing over this screen is furnace coke. Coke passing through this screen is further screened into various sizes. Usual sizes are egg coke, 2½ × 1½ in.; nut coke, 1½ × 1-in.; pea coke, 1 × ½ in.; and breeze, under ½ in., although these sizes may vary somewhat from plant to plant. When coke is scarce, or when the market for the small sizes is limited, everything larger than ¾ in. may be used in the blast furnace. In such cases, a ¾ × 1½ in. or ¾ × 2 in. fraction is prepared and charged into the furnaces separately.

The foregoing screening practice is only a typical example. Many variations are to be found in practice, depending on local conditions and the ideas of the furnace operators. Some plants merely screen furnace coke over a one-inch screen, either with or without the scalping and crushing of sizes over 4 in.

All equipment is controlled from a central station and is electrically interlocked so that the stoppage of any single piece of equipment for any reason whatever will stop all conveyors preceding it in the system.

Conveyor belts for coke handling are 30 to 42 in. wide, of 28 oz, 6 ply duck, with perhaps 3/16 in. top covering and 1/32 in. bottom covering of rubber. The belts run at speeds of 165 to 225 fpm over troughing idler rolls.

The capacity of the coke handling installation usually ranges from 100 to 150 tons of coke per hour.

Coke going to the blast furnace may be loaded into a special transfer car or into standard hopper cars, or it may be moved to the blast furnace coke bins by belt conveyor. The conveyor method seems to be gaining in favor where plant layout will permit it.

BY-PRODUCT RECOVERY

The volatile matter driven off in the coking process consists mainly of a mixture of various hydrocarbons: 1. Hydrogen, H_2; methane, CH_4; ethane, C_2H_6; pro-

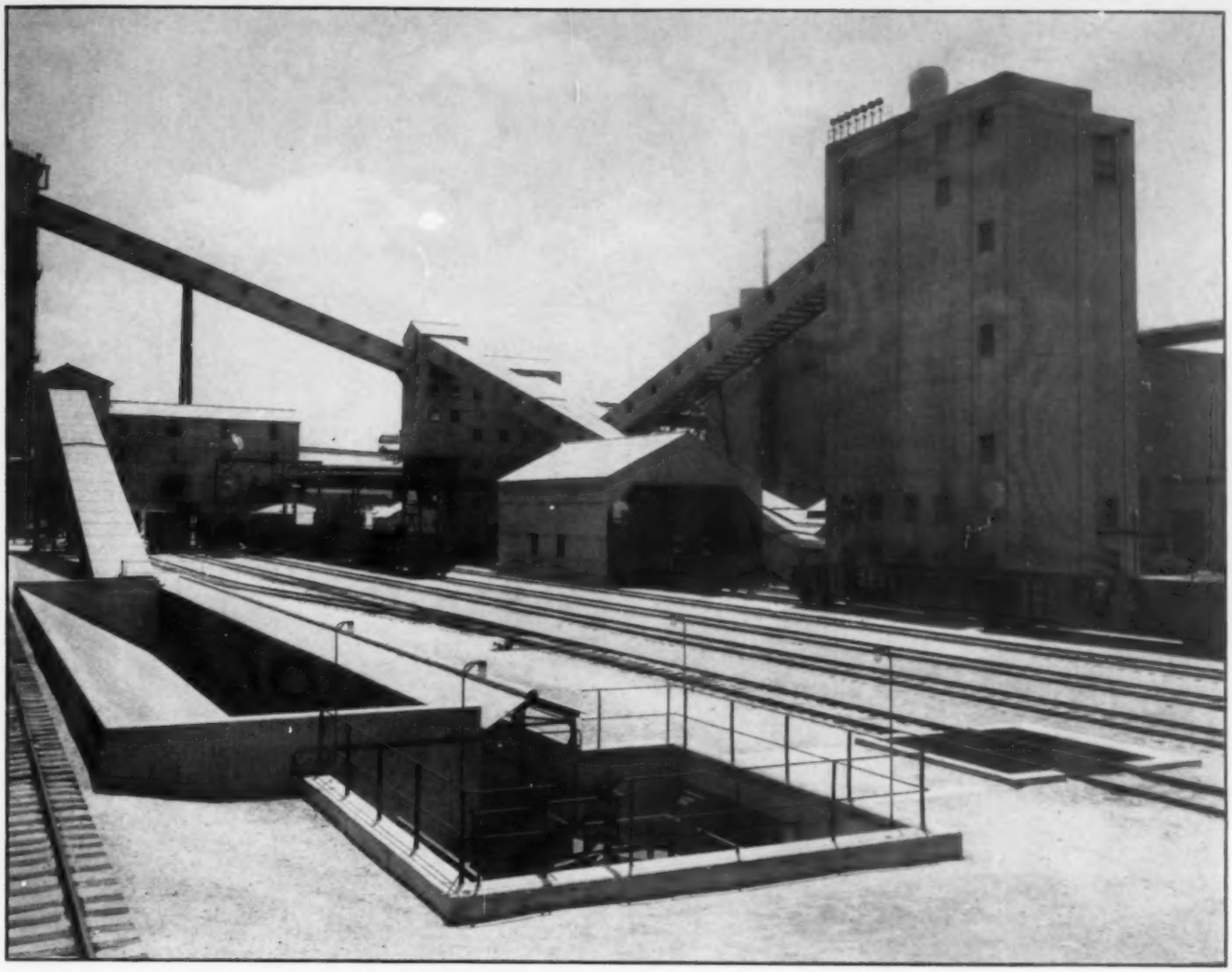


Figure 27— General view of coke plant yard showing in foreground the coke wharf with conveyor leading to screening station. In the background are the coal breaker and mixing buildings.

pane, C_3H_8; butane, C_4H_{10}; ethylene, C_2H_4; propylene, C_3H_6; butylene, C_4H_8; acetylene, C_2H_2; carbon dioxide, CO_2; carbon monoxide, CO; hydrogen sulphide, H_2S; nitrogen, N_2; oxygen, O_2; and ammonia, NH_3.

2. Benzene, C_6H_6; Toluene, $C_6H_5CH_3$; xylene, $C_6H_4(CH_3)_2$; carbon disulphide, CS_2; and aqueous vapors.
3. Naphthalene, $C_{10}H_8$; phenol C_6H_5OH; anthracene, $C_{14}H_{10}$; and heavy pitch-like substances.

The first group are fixed gases, the second are liquid at ordinary temperatures, while the third group are solids.

The products of distillation leave the ovens through refractory lined ascension pipes and pass into the collecting main, which is made of steel plate in a U-shape, with a cross-sectional area of 16 to 19 sq ft, and runs along one side of the top of the battery. The ascension pipes connect into the collecting main through a 13 or 14 in. liquor sealed valve for sealing off the oven (Figure 30). In order to maintain an even pressure, the collecting main may be sectionalized (22 to 37 ovens per section), and in some cases a collecting main is installed on each side of the battery. One or more off-take mains 36 to 42 in. in diameter connect the collecting mains to a 42 to 48 in. main leading to the exhausters.

Ammonia liquor sprays at the valves and in the collecting main reduce the gas temperature from 750 to 1000 F to approximately 200 F, condensing much of the tar and moisture out of the gas. This circulation amounts to 20 to 25 gpm per oven, and is conducted through 6 to 12 in. pipe which follows the gas suction main. Connections of ¾ in. are made into the main and into the ascension pipe valves.

The condensed tar and moisture are washed out of the collecting main by the flushing liquor, and flow through a downcomer and into a flushing liquor decanter or hot drain tank. The collecting main is sloped about ⅛ in. per ft toward the downcomer. The gas passes through the suction main to the primary coolers.

Maintenance of a uniform pressure on the ovens and in the collecting main is essential to good operation. This may be accomplished by a pressure regulator operating a butterfly valve in the offtake main which will automatically maintain the suction to within one millimeter water column. A similar governor on the exhauster maintains constant negative pressure in the suction main.

Primary coolers are generally built in the direct contact design, wherein the gas is drawn up through tanks 50 to 75 ft high and 10 to 12 ft in diameter, coming in intimate contact with cooling liquor flowing down over wooden grids at a rate of 1200 to 2000 gpm. The cooling unit may consist of two towers in series and perhaps two units in parallel. In some installations indirect

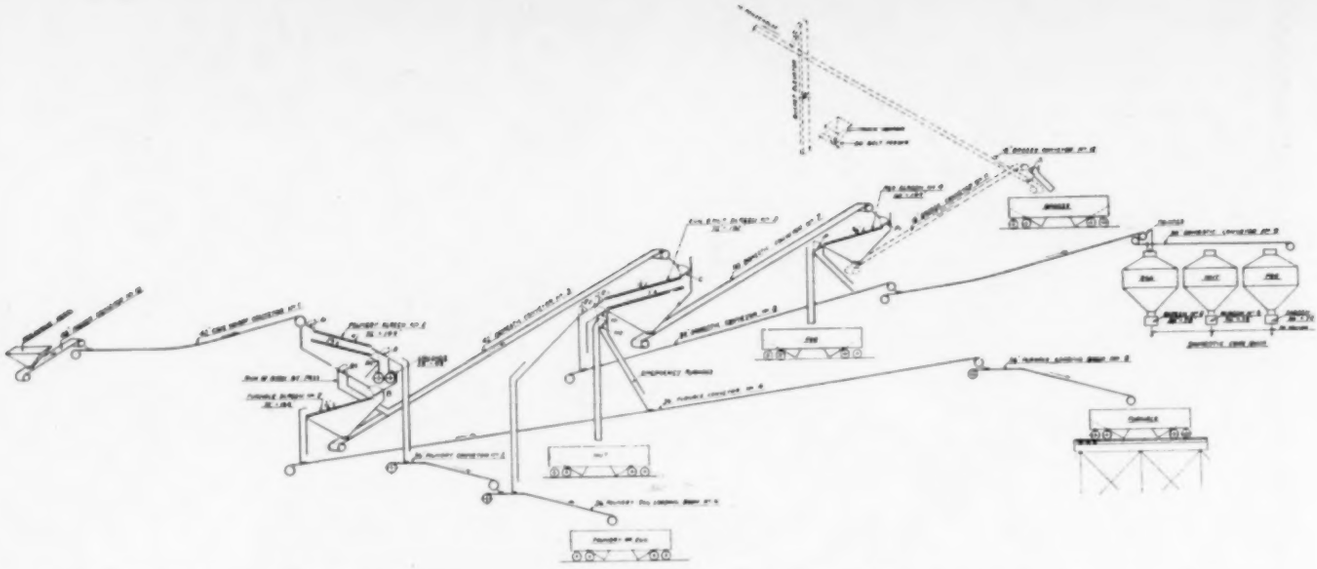
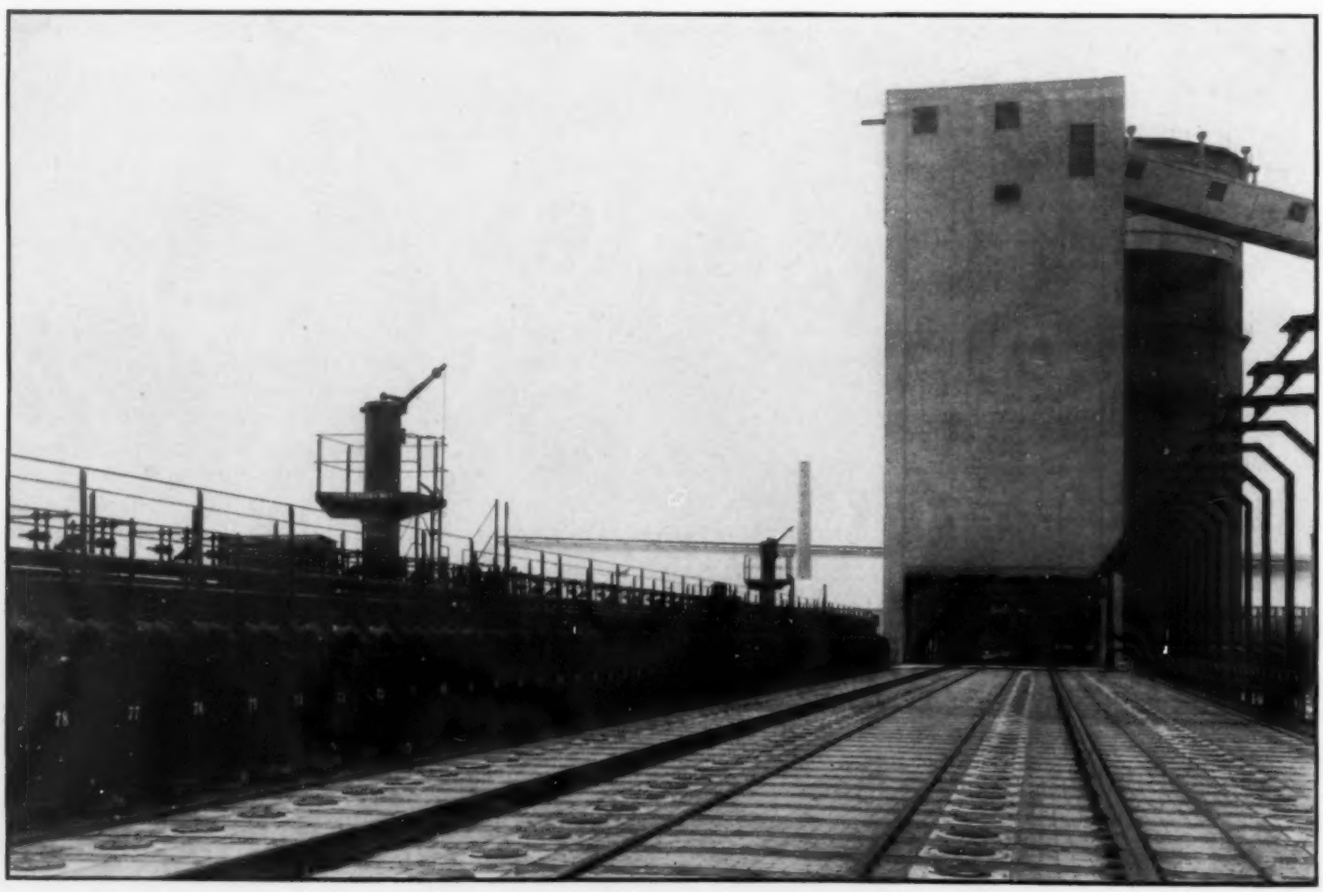


Figure 28 — Layout of a typical screening station which permits almost every desired selection of sizing.

coolers are used. Such units may consist of 2 in. tubes on a shell about 10 ft diameter × 25 ft high, each providing about 18,000 sq ft of surface.

In passing through the coolers, gas temperature is reduced from about 176 F (80 C) to 85 to 90 F (30 to 32 C). About 85 per cent of the tar is condensed out of the gas in the mains, and another 10 per cent in the coolers. The bottom of each cooler is constructed to act as a tank for the separation of tar and liquor. The separated liquor is cooled by passing through pipes around which cold water flows, and is pumped back up to the top of the cooling towers. Tar and excess liquor flows to the flushing liquor decanter.

Figure 29 — Top of oven battery, showing ascension pipes which lead into the collecting main. Charging holes and flue inspection holes may be seen in the battery top. In the background is the oven storage bin with charging larry beneath it.



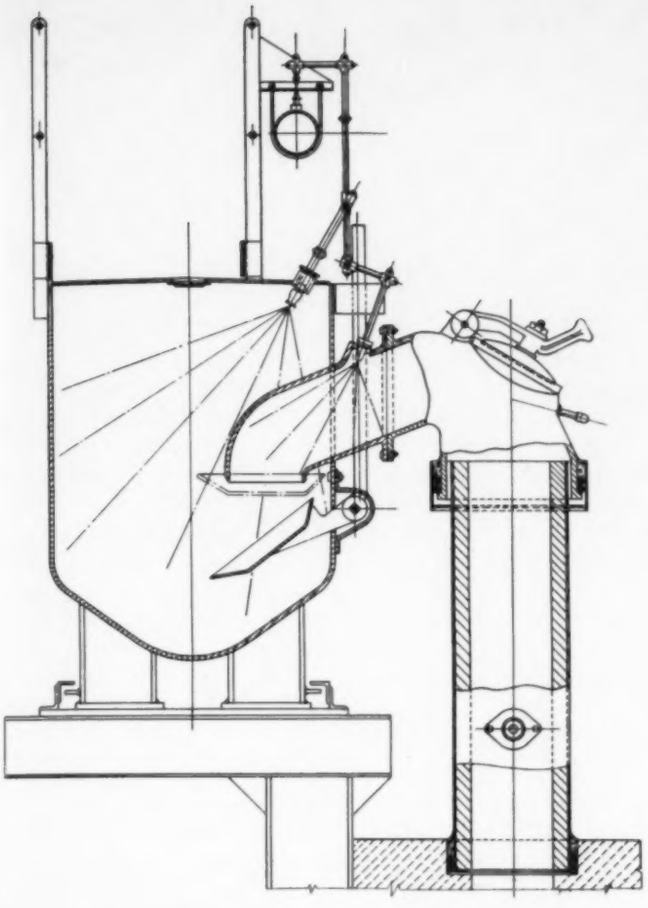


Figure 30 — Section through ascension pipe and collecting main, showing liquor sealed valve which shuts the oven off from the main.

The mixture of tar and ammonia liquor from the mains drains into a decanter, tank or sump, where the tar settles by gravity and flows out continuously. The tar then passes to a separating tank or dehydrator where moisture is eliminated by heating with steam coils. Carbolic oil may also be driven off here as a vapor which may be condensed and pumped to a storage tank. The dry tar is then pumped to the tar storage tanks.

The flushing liquor separated from the tar flows to the flushing liquor circulating tank, from which is pumped the amount needed for sprays in the collecting main, while excess liquor flows to a storage tank.

From the coolers, the gas passes through the exhauster, which is usually a steam turbine-driven unit having a capacity sufficient to take care of the maximum flow of gas the ovens can produce. Depending on the steam balance of the plant, the turbines may be condensing or they may operate against back-pressures of as much as 150 lb, the exhaust steam then being used for steam-driven by-product and benzol pumps, and other equipment. If the exhaust steam is needed only for heating, a back-pressure of 15 psi is usual. The turbines operate under automatic regulators to hold a constant negative pressure in the suction main. An operating pressure range of —10 in. water column to +2½ to 3½ psi is usual. The exhauster pumps gas through the tar extractor or precipitator, through the

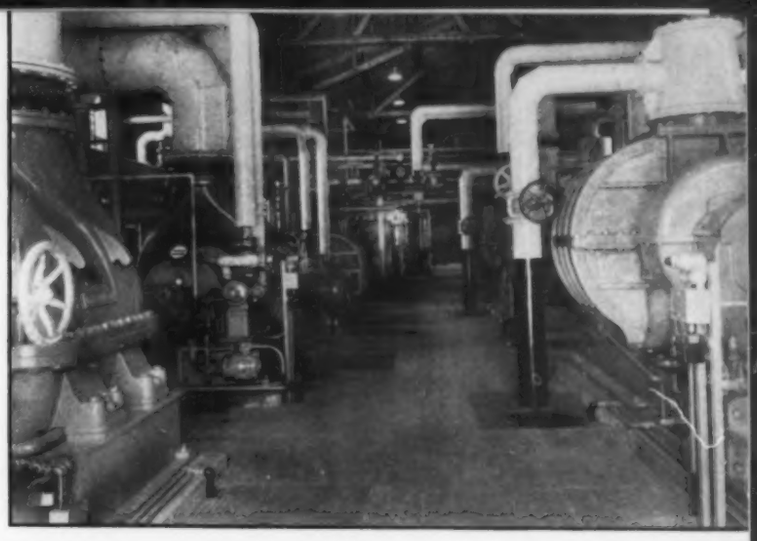


Figure 31 — Typical installation of exhausters and boosters. Steam turbine units normally drive these units.

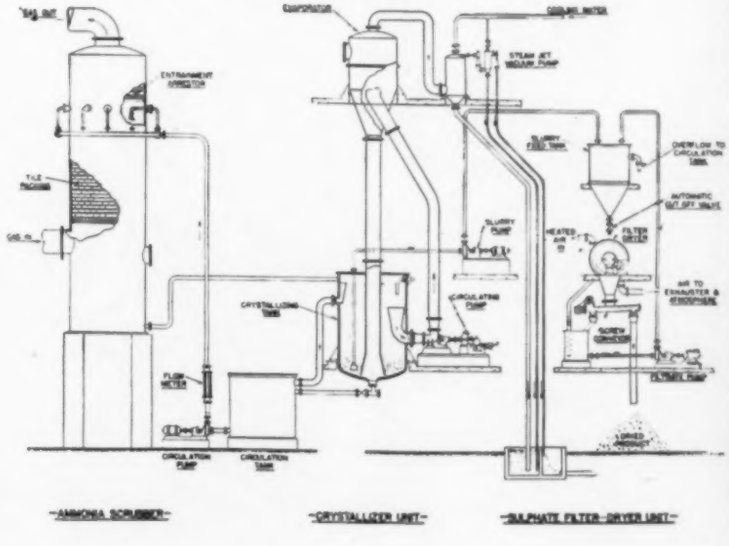
saturator, light oil scrubbers, and gas purifier, and into the gas holder.

The tar extractor, or in the newer plants, precipitator, removes any tar remaining in the gas leaving the exhauster.

The gas next flows through a reheater, where its temperature is raised to about 140 F (50 C), and then bubbles through a sulphuric acid solution (4 to 6 per cent) in the saturator, forming ammonium sulphate crystals. The saturator is a stainless steel lead lined cylindrical unit about 14 ft in diameter. Sulphate crystals precipitate in the bottom of the saturator and are removed and dried.

Another arrangement for sulphate recovery consists of a counter-flow scrubber wherein the gas and ammonia vapor from the ammonia still are sprayed with liquor containing about 5 per cent of sulphuric acid. This solution joins the circulating solution in a crystallizing tank and is pumped up to an evaporator. Thus, the solution is brought to a supersaturated condition and circulated through the suspended mass of crystals

Figure 32 — Flow diagram of one type of saturator equipment for the production of ammonium sulphate.



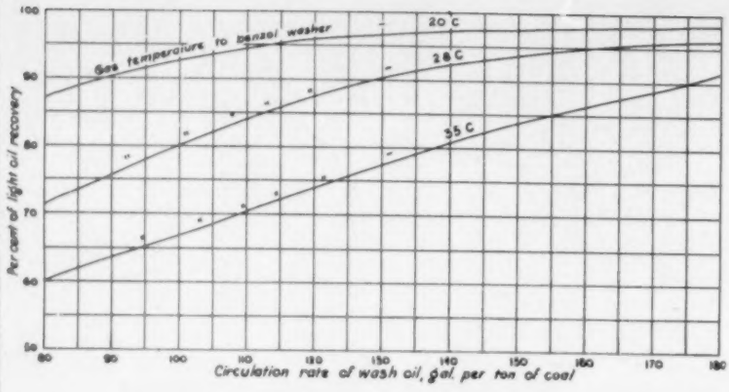

Gas temperature to benzol washer
20 C
28 C
35 C
Percent of light oil recovery
Circulation rate of wash oil, gal. per ton of coal

Figure 33 — Curves showing effects of gas temperature and rate of circulation of wash oil in benzol washers upon light oil recovery.

in the crystallization tank. Crystallization thus proceeds, and the heavier crystals gravitate to the bottom of the tank and are pumped to a slurry feed tank. From this tank, sulphate crystals are fed to a filter-dryer and finally discharged to storage (Figure 32).

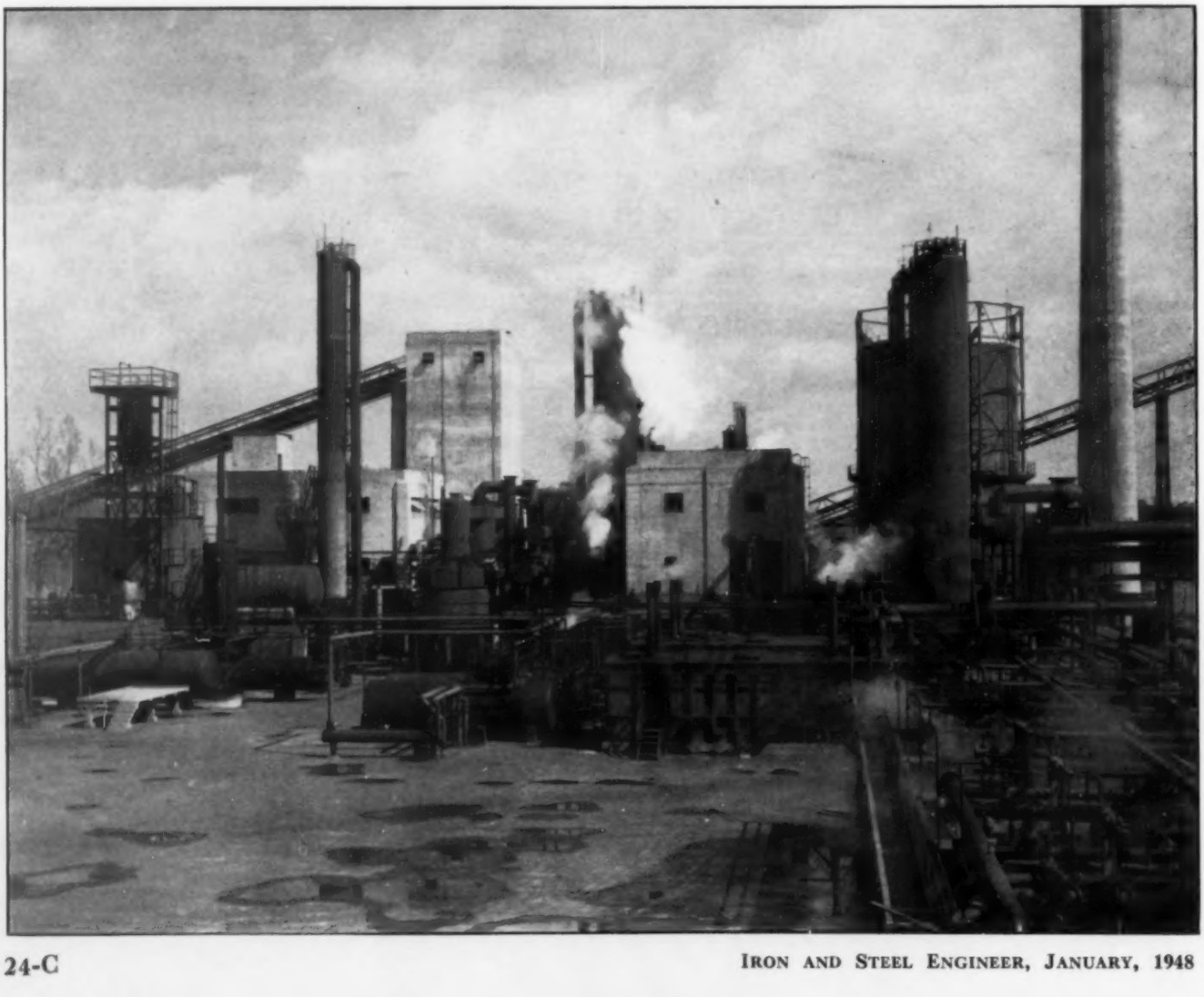
At times the demand for ammonium sulphate, which is used principally as fertilizer, has not kept up with the productive capacity. Hence, some plants have not installed sulphate equipment, but merely scrub the ammonia out of the gas, and concentrate and sell the liquor.

The ammonia liquor condensing in the mains and coolers usually contains 1.0 to 1.5 per cent NH_3, although this depends to a great extent upon the free and combined moisture in the coal.

The ammonia still is usually a cast iron tower 4 to 5 ft in diameter × 30 to 40 ft high, containing 15 to 20 bubble trays. In the still, the liquor is brought into contact with steam heated milk of lime, which breaks up fixed ammonia combinations. Lime consumption runs 2.0 to 2.5 lb per ton of coal coked. Ammonia vapors pass out of the still, and may be condensed to form concentrated ammonia liquor or, if the plant is equipped to produce ammonium sulphate, it may be piped back into the gas stream ahead of the sulphate equipment.

From the by-product apparatus, gas flows to the light oil scrubbers. If the gas has been heated for the recovery of ammonium sulphate, it is passed through a final cooler, about 11 ft in diameter × 85 ft high, of direct contact, hurdle type, where water sprays reduce gas temperature to 60 to 80 F (16 to 27 C). Naphthalene

Figure 34 — By-products area of coke plant. From left to right are seen: ammonia sulphate building, saturator tank, exhauster and booster building, gas holder in background, and ammonia liquor cooling coils.



is condensed out here, and separating sumps are usually installed from which naphthalene is conducted to a storage tank.

Light oil scrubbers are 60 to 100 ft high and 10 to 12 ft in diameter, with a primary and secondary unit in series, and, in large plants, two such combinations in parallel. They contain wooden hurdles or steel spiral mesh packing through which the gas rises, while wash oil, sprayed in at the top of the scrubbers, flows down over the hurdles. The wash oil first passes through the secondary scrubber, and then through the primary scrubber, absorbing in its passage 90 to 95 per cent of all the light oil vapors in the gas.

Wash oil is usually a product of the refining of petroleum. It should have a specific gravity not over 0.88, which flows readily at 35 F and which will distill about 90 per cent between 480 F and 660 F. Wash oil at 75 F will absorb light oil equal to 2 to 3 per cent of its own weight. Wash oil consumption may run 0.14 to 0.20 lb per ton of coal coked, while a circulation rate of 100 to 200 gal per ton of coal coked may be used, depending on the temperatures of the gas (see Figure 33) and wash oil, and upon the degree of light oil recovery desired. A rate of 165 gal per ton of coal, is a fair average for good recovery.

For maximum recovery of light oil, the temperature of gas entering the scrubbers should be 70 to 75 F (21 to 24 C), while wash oil should be about 4 degrees higher. Wash oil should not be too viscous, nor should it emulsify with water. Scrubber should give ample contact surface, and the rate of oil circulation should be such as to require not over 3 per cent absorption of the oil. Circulation rates of 150 to 200 gal of wash oil per ton of coal coked are usual.

The gas, free from all by-products, then flows to the gas holder. Some plants have a small holder for the gas to be used as oven fuel, with a set of automatic valves operated by this holder so as to keep the fuel gas holder full while diverting surplus to the large holder.

Typical of these holders are those installed in a recent plant, where a single lift fuel gas holder of 20,000 cu ft capacity, 15 in. water gage pressure, was provided. A surplus holder of dry seal type, 89 ft in diameter × 183 ft high, provides storage for 1,000,000 cu ft of gas at 12 in. water gage pressure.

Coke oven gas contains 350 to 500 grains of hydrogen sulphide per 100 cu ft. Purification is essential if the gas is to meet the requirements of metallurgical heating processes and the more stringent requirements of domestic use.

Several methods are employed for sulphur removal. In one method, the gas is washed with a solution of sodium carbonate, by which as much as 95 per cent of the hydrogen sulphide can be removed. Under ordinary circumstances, 0.1 to 0.2 lb of soda ash is consumed per ton of coal coked. The spent solution leaving the bottom of the tower may be reclaimed for further use by aeration in an actifier column, or it may be actified with steam at high vacuum. In the latter case the hydrogen sulphide may be collected for the production of sulphuric acid or otherwise disposed of. Hydrogen cyanide may also be recovered and converted into sodium cyanide.

In another method, the gas is scrubbed with ammonia liquor, which absorbs sulphur and is then subjected to steam as it flows over trays in a sulphur eliminating column, driving off the hydrogen sulphide. The liquor is then cooled and reused in the sulphur scrubber.

Still another process removes hydrogen sulphide from gas by scrubbing with a sodium thioarsenate solution. This solution is actified by air under pressure in a thionizer, where the sulphur is filtered off. This filter cake is then melted in an autoclave recovering the sulphur.

The iron oxide filter, used to a considerable extent in the gas industry, has not been widely used in coke plants of the steel industry.

In some plants, only the surplus gas is purified, the process being inserted just ahead of the surplus gas holder. Other plants purify all of the gas, with the equipment installed just ahead or after the light oil scrubbers.

Reclamation of light oils from the enriched wash oil is accomplished by distillation, which is accomplished over a considerable range of temperatures. Older plants use the so-called high temperature process, wherein the temperature of the enriched wash oil is brought to 293 to 302 F (145 to 150 C) before it enters the wash oil still. Some low temperature plants were designed using temperatures of 194 to 212 F (90 to 100 C). More recent plants have adopted a medium temperature of about 248 F (120 C). In these installations the enriched wash oil from the light oil scrubbers is pumped through a vapor-to-oil heat exchanger, where its temperature is raised to about 194 F (90 C), and a final heater which raises the temperature to about 257 F (125 C). The benzolized wash oil then enters the top of the stripping or wash oil still, where it flows down over a series of trays while steam admitted at the bottom passes upward, distilling out the light oil vapors. This still is 6 to 9 ft in diameter and 40 to 50 ft high, and contains about 12 bubble trays. Steam flow is about 0.65 lb of steam per gallon of wash oil circulated.

For maximum recovery of light oil, wash oil should be completely freed of its light oil content, and its naphthalene content should be reduced to 5 per cent or less before recirculation. Actually, debenzolization of wash oil down to 0.35 per cent or less by volume of light oil at 200 C represents good still operation.

As debenzolized wash oil leaves the wash oil still, muck and water are removed by decanting, and the oil is subsequently cooled to about 75 F (24 C) in a cooler containing perhaps 6400 to 8500 sq ft of surface for each battery of ovens served. A wash oil purifier may also be used for muck removal. In this unit, a small part of the partially debenzolized wash oil from the stripping still is vaporized by steam which is then used in the stripping still. These vapors return to the still, while the muck is left in the purifier as a residue.

Light oil vapors and steam pass out of the top of the stripping still, through the other side of the previously mentioned vapor-to-oil heat exchanger, through separators which remove water and wash oil, and finally through a condenser and to crude storage. In more recent plants, a rectifying column or crude residue separating column is inserted ahead of the condenser. A primary purpose of this column is to separate continuously the heavy fractions from light oil without a separate crude run. This separation may vary in differ-

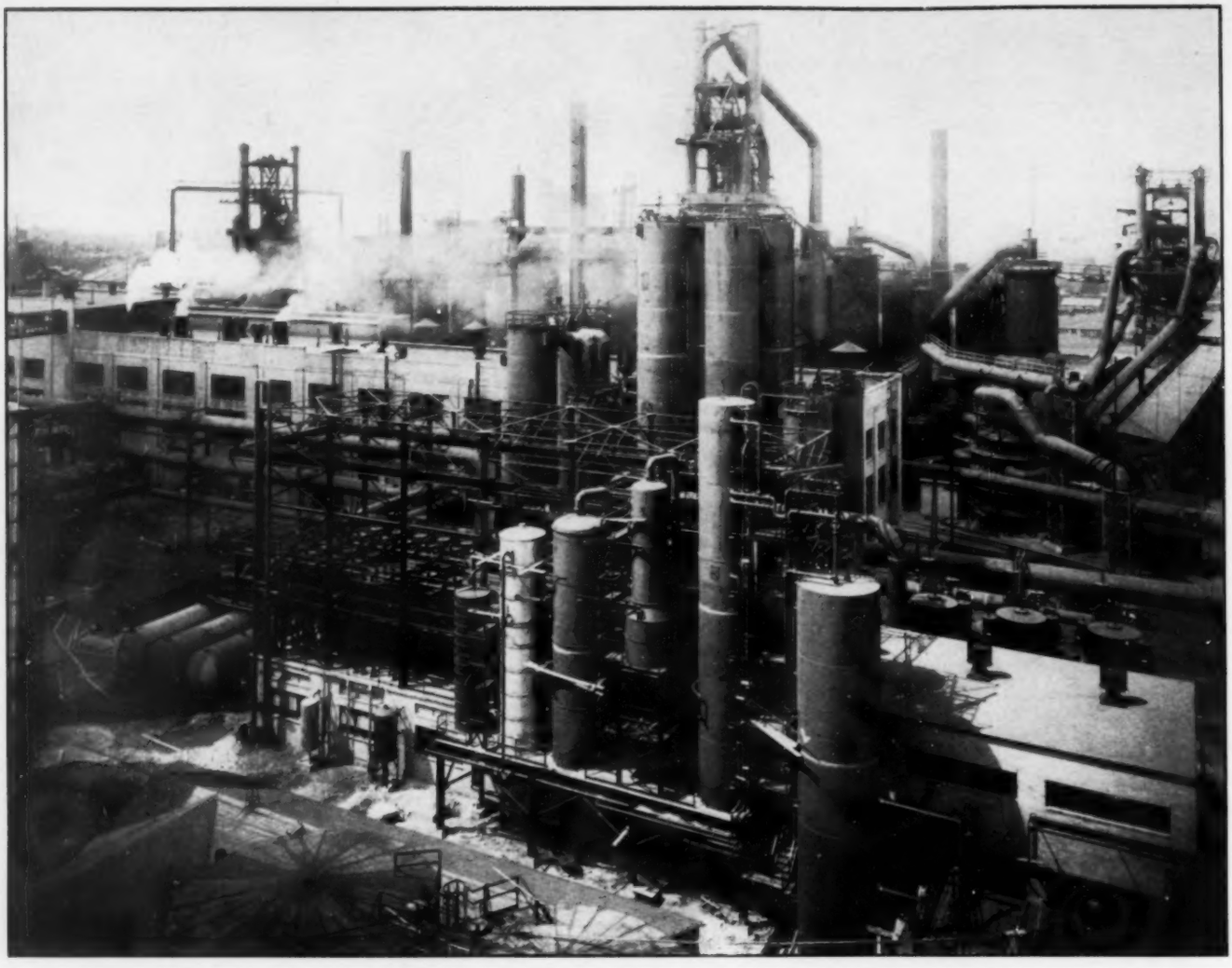


Figure 35 — General view of by-product plant showing the pump room and exhauster building with the phenol plant, light oil stills and ammonia still in the foreground. The coolers and scrubbers are in the background.

ent plant systems, and the treatment in this column likewise varies. If the wash oil still operates at high temperatures, the action in the separating column is one of cooling, usually by cool light oil flowing over the trays in the column. If the wash oil still uses low temperatures, some steam must be used in this column. The recent trend is to separate material boiling above 302 F (150 C), including crude heavy solvent, naphthalene, wash oil, etc., from the remainder of the light oil.

Fractionating and refining the light oil may be accomplished in several ways. In the older plants, the batch system prevails, but in the more recent plants, continuous or semi-continuous systems prevail. In all systems, the oil is heated to a definite temperature to vaporize the desired fraction, which is then condensed and run to a storage tank. The temperature of the oil which remains unvaporized in the first heating is then raised to vaporize the next fraction.

In the batch system, two stills are generally used, a crude still and a pure still. Batch type stills are usually of boiler type, heated by steam coils, and surmounted by rectifying columns 35 to 55 ft high. The crude light oil is first separated into three or more fractions. A quantity of light oil is charged, which may range 20,000 to 55,000 gal, and the still temperature is gradually raised. The first product, which evolves with a still temperature of 149 F (65 C), is termed "fore-runnings," and consists of benzol containing some carbon bisulphide.

The next product, given off with a still temperature of 176 F (80 C), is crude benzol. Next, with a still temperature of 230 F (110 C), crude toluol is driven off. When the temperature is raised to 248 to 284 F (120 to 140 C), light solvent naphtha is driven off, and finally, at 302 F (150 C), heavy solvent naphtha is produced. Each of these runs is continued until tests on the products indicate that that particular step is completed. The residue in the still is wash oil and naphthalene, the latter solidifying when cooled.

The foregoing separations are only approximate, and the various fractions are stored in crude oil storage tanks. Usually, complete fractionation as set forth above is not carried out in the crude still; three fractions are more usual.

Crude still products contain paraffins, unsaturated hydrocarbons, and other impurities, the removal of which is accomplished by washing the oils with an acid solution. The crude oil is placed in an agitator and sulphuric acid is added. The agitator is about 10 ft in diameter × 10 to 18 ft high, and has a capacity of 5000 to 7500 gal. Most of the existing agitators are of

cast iron construction and lined with lead. Recently, stainless steel has been adopted for agitator construction. The quantity of acid required for washing depends on the specifications to be met by the product. About one lb of acid for each 5 gal of oil is a fair average.

After washing and settling, the sludge is drawn off and the mixture in the agitator is washed with a 10 per cent caustic soda solution until all traces of acid are neutralized. Between 0.2 and 0.4 lb of caustic soda is consumed per ton of coal coked.

Subsequent distillation in the pure still further refines the light oil fractions into chemically pure products or into mixtures that require redistillation. The pure still may be operated so that at least one fraction will be pure. For example, a charge of washed crude benzol is put into the pure still and separated into approximately 8 per cent rerun benzol containing carbon disulphide, 62 per cent pure benzol, and 5 per cent rerun benzol containing toluol, with a 25 per cent residue of toluol. The pure benzol is ready for shipment, and the other three items are stored separately until sufficient quantities are accumulated for a still charge for redistillation.

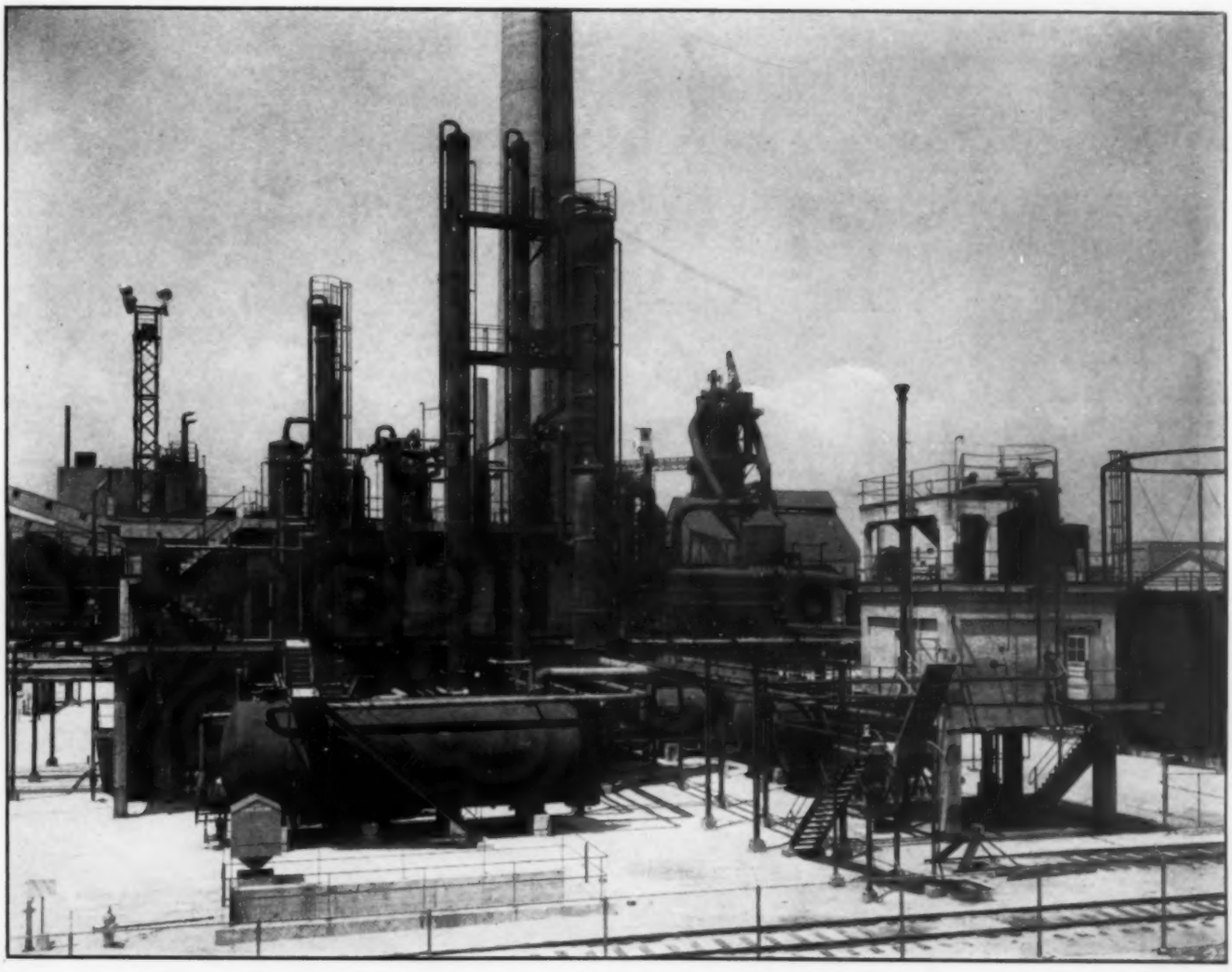
Then the still may be charged with rerun benzol and separated into about 14 per cent rerun benzol containing carbon disulphide, 60 per cent pure benzol, 10 per cent rerun benzol containing toluol, 3 per cent rerun toluol containing benzol, 7 per cent pure toluol, with a 6 per cent residue of toluol and solvent naphtha. Again, the impure fractions are stored separately until enough is accumulated for a still charge.

A charge of rerun toluol may separate into 10 per cent rerun benzol containing toluol, 30 per cent rerun toluol containing benzol, 40 per cent pure toluol and 2 per cent rerun toluol containing naphtha, with an 18 per cent residue of toluol and naphtha.

Batch still temperatures are about 176 F (80 C) for pure benzol, 219 F (104 C) for pure toluol and 254 F (123 C) for pure solvent.

In the continuous process of light oil refining, the principle of distillation is likewise, but the oil flows continuously through a succession of fractionating columns. In a typical installation, the crude light oil, after being washed with acid and caustic soda solution, as previously described, passes through a residue removal column in which light oil is fed at a constant rate into

Figure 36 — General view of benzol plant showing light oil refining stills.



the still column, while live steam is introduced at the base of the column at a controlled rate sufficient to vaporize all light oil except the polymerized impurities, which remain in the still as a residue which is drawn off into storage tanks. A unit of this type may operate with a top temperature of 163 F (73 C) and a bottom temperature of 214 F (101 C). The vaporized light oil is condensed and separated from water by decanting, and passed on to storage tanks.

The light oil is then passed continuously through two to four boiler-still fractionating columns in series with steam coils supplying heat to vaporize the oil entering the unit. The vapors pass off through the fractionating columns, through a condenser and after cooler, and into product receiving tanks where it is held until tests show it to be satisfactory, when it is transferred to a product storage tank. The oil remaining unvaporized in the base of each still is pumped to feed the following column. Thus, by regulating temperatures in each column, the desired fraction is driven off as a vapor, while the remainder passes to the next still.

In systems of this type, the first column following the residue removal unit may be used as a forerunnings column or to produce motor benzol, the next to produce pure benzol, and the final column, pure toluol, xylol and solvent naphtha. If intermediate material with boiling points between those of toluol and benzol is present to any extent, another distillation unit would be required between the second and third columns mentioned above. Use of the various units may be varied somewhat from the foregoing, according to local conditions and the desires of the operator.

Still temperatures, measured at the middle of the columns, are held at approximately 190 F (88 C), 203 F (95 C), and 252 F (122 C), respectively, for motor benzol, pure benzol and pure toluol. Xylol is a side cut product from the pure toluol column, and is collected as a liquid by trays near the bottom of that column. Any product with a boiling point above that of solvent naphtha accumulates in the last boiler still and are drained off to storage from time to time.

A number of the newer plants are designed with a semi-continuous process of light oil refining. A typical unit of this type passes the light oil (after separating it in a rectifying column) through a continuous CS_2 or forerunnings column. This unit consists of a steam coil heated reboiler and a column about 24 in. in diameter × 85 ft high, and containing about 35 trays. Its primary purpose is to reduce sulphur content of the light oil. Operating temperatures of this column are approximately 122 F (50 C) at the top and 203 F (95 C) at the bottom, although the column can be operated over a wide range of conditions to meet local conditions and demands. Forerunnings vapors leave the top of the column and pass through a condenser. Gases are vented off, often into the oven fuel gas.

The bottoms from the CS_2 column are next fed to a motor fuel column, a continuous unit consisting of a steam coil heated reboiler and a column approximately 24 in. in diameter × 75 ft high containing about 30 trays. This column can be operated in a number of ways, so that it can be used to produce pure benzol when required. In such cases, this column is fed with cooled, acid-washed bottoms from the CS_2 column.

The motor fuel column operates similarly to the CS_2 column. Vapors leave the top of the column, pass through a condenser, and on to storage tanks. The bottoms drain through a cooler into storage, and are subsequently acid-washed preparatory to being charged to a batch still for pure products fractionation. By reducing the temperature in the still, any portion of the benzol can be left in the bottom products for refining in the pure still. When this still is charged with acid-washed secondary light oil, a number of products may be withdrawn in succession, including nitration benzol, nitration toluol, 2 to 5 degree xylol, motor fuel, 90 per cent benzol, industrial benzol, industrial toluol, 10 degree xylol and washed solvent naphtha.

In the operation of the various fractionating columns described above, an important factor in their control is the use of reflux, or recirculation of some of the condensed product back into the column. The ratio of reflux used may vary over very wide ranges.

Many other by-products may be recovered, such as phenol, carbolic oil, pyridine, etc. Phenol may be extracted from hot ammonia liquor from the ammonia still by treatment with a solution of caustic soda, giving sodium phenolate. In another system, the primary cooler liquor (prior to the recovery of ammonia) is washed with light oil which absorbs phenol from the liquor. The phenolized light oil is then treated with caustic soda solution, giving sodium phenolate. The light oil is then recycled.

Carbolic oil may be recovered from tar, being vaporized by heating the tar (which also removes water from the tar). These vapors are condensed, the water decanted off, and the carbolic oil sent to storage.

Pyridine, which accumulates in the ammonium sulphate solution of the saturator, may be recovered by continuously drawing off a small quantity of this solu-

Figure 37 — Effect of rank of coals on coke properties.

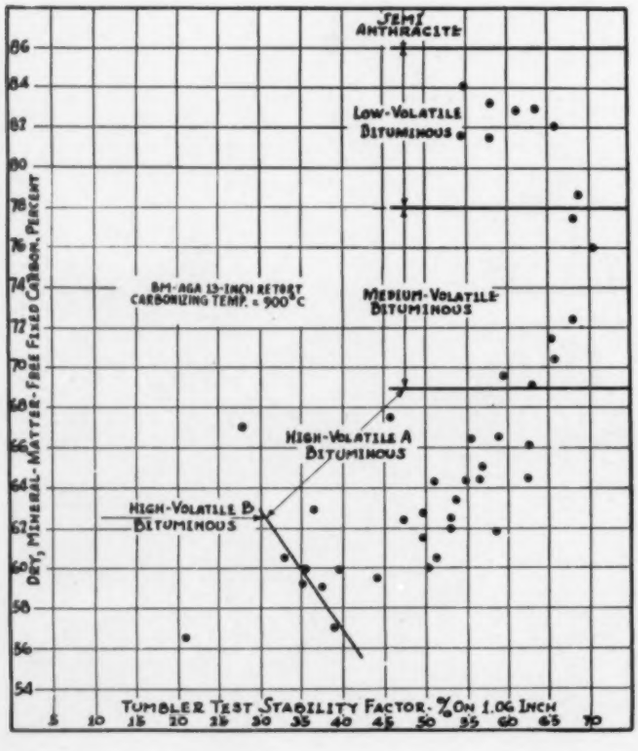


TABLE VII

COKE PLANT OPERATING PERFORMANCE

	Plant A	Plant B	Plant C	Plant D	Plant E	Plant F	Plant G
Analysis of coal:							
Volatile matter, per cent	33.60	31.10	32.5	28.3	28.5	30.8	30.3
Fixed carbon, per cent	57.17	61.40	62.1	.....	.....	.....	.....
Moisture, per cent	2.75	2.68	4.0	4.9	6.3	6.6	3.8
Ash, per cent	9.25	7.44	5.4	7.8	7.5	6.9	6.5
Sulphur, per cent	1.01	0.87	0.78	0.85	0.84	1.06	0.82
Analysis of coke:							
Volatile matter, per cent	0.67	1.01	0.8	1.1	1.4	1.4	1.6
Fixed carbon, per cent	87.85	89.20	92.7	.....	.....	.....	.....
Ash, per cent	11.79	9.80	6.5	9.3	9.5	9.3	9.0
Sulphur, per cent	0.72	0.71	0.61	0.63	0.83	0.83	0.65
Moisture, per cent	1.11	1.78	3.00	3.3	6.3	1.0	0.5
Oven width, in. (average)	14	14	17	16.50	17.25	17	17.25
Gross coking time, hr–min	11–46	13– 4	.....	.....	.....	.....	.....
Net coking time, hr–min	11–26	12–30	17–0	16–20	15–8	15–8	17–5
Coal charged per oven, net tons	.....	12.5	18.0	12.2-14.3	17.0	17.41	18.02
Total coke yield, per cent	75.75	76.0	74.1	77.7	73.7	77.69	79.0
Furnace coke yield, per cent	63.07	61.0	65.0	.....	.....	.....	.....
Domestic coke yield, per cent	6.98	10.0	3.7	.....	.....	.....	.....
Pea coke yield, per cent	0	0.5	1.5	.....	.....	.....	.....
Breeze yield, per cent	5.70	4.5	3.9	6.0	4.2	7.22	8.0
Tar, gal per ton of coal	11.03	11.3	8.85	6.7	6.2	6.96	8.8
Ammonium sulphate, lb per ton of coal	25.21	25.5	.....	18.1	19.9	15.94	21.6
Light oil, gal per ton of coal	3.6	3.4	3.25	2.9	2.9	.....	.....
Ammonia liquor, gal per ton of coal	.....	14.0	.....	.....	.....	.....	.....
Total gas, cu ft per ton of coal	10,130	10,200	10,200	10,353	10,234	10,719	12,053
Gas to heat ovens, cu ft per ton of coal	.....	3900	.....	4356	4465	.....	.....
Surplus gas, per cent	.....	61.8	.....	58.0	57.3	.....	.....

tion, and passing it through a neutralizer in which the solution is maintained neutral by ammonia vapor. As neutralization proceeds, pyridine separates out and is decanted off in a separating tank.

PRODUCTS

In the steel industry, the primary purpose of the coke plant is of course to produce coke for the blast furnaces. The by-products, however, are of such value as to offset the cost of coking.

In typical American by-product practice, one net ton of coal will produce:

Furnace coke, lb	1200-1300
Nut coke, lb	100- 200
Coke breeze, lb	80- 150
Coke oven gas, cu ft	9900-11,500
Tar, gal	8- 12
Ammonium sulphate, lb	20- 28
Liquor, gal	12- 35
Light oils, gal	2½- 4

These yields depend to a great degree on the coal used, the coking temperature, and the method of recovery.

Coke for the blast furnace must have definite physical and chemical properties which determine whether or not it will work satisfactorily in the furnace. Actually, blast furnaces in the United States operate successfully with cokes ranging 6 to 14 per cent ash and 0.5 to 1.8 per cent sulphur, with porosity of 40 to 60 per cent, a 2 in. shatter index of 10 to 75 per cent, and a wide range of specific reaction rates and of mean size charged. Such variations stem from the dependence of these properties upon the coal that is available at a cost conducive to economical operation, and to a lesser extent upon coking practice.

However, while coke of such widely varying charac-

TABLE VIII

TYPICAL COKE ANALYSES

Kind of coal	Per cent by weight									
	H_2O	Volatile	Fixed carbon	Ash	S	P	SiO_2	Al_2O_3	Bases	Fe
Connellsville, Pa.	0.32	1.70	86.50	11.50	0.75	0.020	5.30	3.00	4.30	2.60
Pocahontas, W. Va.	.....	2.31	90.62	6.97	0.70	.....	.....	.....	.....	.....
New River, W. Va.	.....	2.82	90.52	6.36	0.70	.....	.....	.....	.....	.....
Davis, W. Va.	0.33	1.20	87.97	10.50	0.55	0.034	4.27	3.89	.....	1.40
Derry, Pa.	.....	2.50	81.60	14.70	1.20	.....	.....	.....	.....	.....
Webster, Pa.	.....	1.10	88.40	10.50	0.95	0.03	4.80	3.50	.....	1.85
Klondike, Pa.	.....	2.50	84.50	12.00	1.00	.....	.....	.....	.....	.....
Loyalhanna, Pa.	.....	2.45	81.20	15.00	1.35	.....	.....	.....	.....	.....
Mountain, Pa.	0.50	1.10	85.85	11.53	1.00	0.018	.....	.....	.....	.....
Fairmount, W. Va.	0.30	0.97	87.43	11.30	1.35	0.020	4.16	2.53	.....	2.45

TABLE IX

SPECIFIC HEAT OF COKE

Temperature F		Mean specific heat, Btu per lb per degree F			
		Coke with ash content of			
	Ash	5 per cent	10 per cent	15 per cent	20 per cent
400	0.204	0.225	0.224	0.223	0.222
750	0.227	0.277	0.275	0.272	0.269
1,100	0.242	0.313	0.309	0.306	0.302
1,500	0.250	0.337	0.333	0.328	0.324
1,800	0.256	0.356	0.351	0.345	0.340
2,000	0.258	0.363	0.359	0.353	0.348

teristics is used satisfactorily among the various blast furnaces, the coke going to an individual furnace must be uniform in physical structure, size, strength and chemical composition if good operation is to be expected. Adjustments can be made to accommodate a coke of poor but uniform quality, but a smooth operation cannot result with a coke of good but varying quality.

Good furnace coke should resist abrasion, and must not break up in the furnace. It should be hard but not brittle. Open cell structure in the coke favors rapid combustion, while a dense structure retards combustion.

A number of tests have been developed for measuring the quality of coke. Chemical tests ordinarily made are proximate analysis and sulphur determination. Occasionally, fusion point of ash, phosphorus content and ultimate analysis are also determined. Physical tests may include shatter, tumbler and screen analysis, and, in some cases, determinations of porosity and reactivity as well. Although standards of procedure for these tests have been set up, many modifications have been introduced. Some plants regularly use some or all of the tests; some use no physical tests.

In spite of much work, it is still impossible to predict accurately, from laboratory tests, the behavior of coke in the blast furnace. What works in one plant may be quite unsatisfactory in another, and two furnaces in the same plant may work quite differently on the same coke. The real answer is to be had only from actual use in the blast furnace.

Coking practices affect coke quality to a considerable degree. Harder coke is obtained from pulverization to 70 per cent through $\frac{1}{8}$ in. mesh than if pulverized to 50 per cent through $\frac{1}{8}$ in. Excessive coking temperatures may cause the coke to break up easily. Hence high coking rates may give smaller coke. If coking temperature is too low, however, the coke does not effectively resist abrasion. High moisture in the coal charged to the ovens tends to increase the porosity of the coke. Low moisture gives a denser coke.

Coke yields obtained from various coals are closely proportional to the rank of the coal as measured by its fixed carbon, running 102 to 113 per cent of the fixed carbon plus ash content of the coal as carbonized. The coke yield is greater than the fixed carbon plus ash contents because of the deposition of carbon by thermal decomposition of hydrocarbons in gases and vapors passing through the coke mass. When coke yields (dry) are plotted against fixed carbon plus ash, a straight line satisfies the points nicely, and the formula for this relation may be developed as:

$$\text{Per cent coke yield, dry} = 19 + 0.79\ (C + A)$$

where C equals per cent of fixed carbon in coal as carbonized, and

A equals per cent of ash in coal as carbonized.

The ash content of the coke, which equals the ash content of the coal divided by the coke yield may therefore be expressed:

$$\text{Per cent ash in dry coke} = \frac{100\ A}{19 + 0.79\ (C + A)}$$

with symbols as above.

Coke yield drops as the carbonizing temperature is increased up to about 1650 F, due to the more complete driving off of the volatile matter, which reaches a minimum of about one-half per cent at this temperature. The carbon content of the coke increases, and the Btu per pound of coke decreases simultaneously. Above 1650 F, the coke yield increases slightly due to carbon deposition.

The tests also show that, other things being equal,

TABLE X

VARIATION IN GAS COMPOSITION AS COKING PROGRESSES

Hours coking	CO_2	C_6H_6	C_2H_4	O_2	CO	CH_4	H_2	N_2	Heat value. Btu per cu ft
2	3.30	1.80	4.00	1.05	0.90	36.65	42.50	10.00	606
4	2.30	1.10	3.10	0.60	2.90	34.50	48.80	6.70	570
6	2.20	1.00	2.80	0.50	3.00	33.60	50.10	6.80	560
8	1.40	0.60	2.50	0.20	3.40	33.65	53.75	3.60	550
10	2.30	0.35	1.75	0.20	2.80	31.20	47.10	14.30	485
12	1.50	0.35	1.85	0.20	4.15	33.40	50.65	7.90	525
15	1.90	0.25	1.80	0.15	3.90	33.20	53.40	5.40	525
19	1.10	....	1.20	0.15	4.70	26.10	55.75	11.0	450

coke from high-rank (low-volatile) coals is stronger than that from lower ranks, and that strength decreases and density increases as the temperature of carbonization increases.

Sulphur content of the coke is found to vary in direct proportion with the coal, and this relation can be expressed by the equation:

$$\text{Per cent sulphur in coke} = 0.82 \times S$$

where S = per cent sulphur in coal as carbonized.

Table VIII gives analyses of coke from coals of various origin.

Coke has a specific gravity of 1.2 to 1.4, and a calorific value of about 13,000 Btu per lb. When piled, coke weighs 26 to 32 lb per cu ft. Table IX gives the specific heat of coke.

Gas made by one net ton of coal may range between 9300 and 11,000 cu ft, with an overall average of about 10,350. High rank Appalachian coals give gas yields roughly proportional to their volatile content, but for coals high in oxygen, the proportionality does not hold. High resin content in the coal increases gas yields. Operation and condition of the ovens may cause even greater variations. For example, for a given coal, gas yield varies directly with coking temperature at a rate of about 1500 cu ft per ton for each 100 degrees F temperature change. Accordingly, no simple factor can be found to serve as a definite indicator of the gas yield to be expected from a given coal.

Carbonizing temperature influences the composition of the gas, as well as the quantity. As the temperature is increased, hydrogen and carbon monoxide increase while ethane and methane decrease; calorific value and specific gravity of the gas also decreases.

Composition of coke oven gas from a given oven also varies as coking proceeds, being richest at the beginning of the period and gradually thinning out toward the end of the period. This is exemplified by the gas analyses in Table X, taken from the same oven at various times during the coking period. However, since the total gas make comes from many ovens at various stages of coking, the average gas analysis will normally remain quite uniform.

Coke oven gas weighs 0.0285 to 0.0305 lb per cu ft. It has a specific heat of 0.0194 to 0.0000047 t, and a specific gravity of 0.34 to 0.040. Its calorific value ranges 480 to 580 Btu per cu ft before light oil extraction, and 35 to 45 Btu per cu ft less after debenzolization.

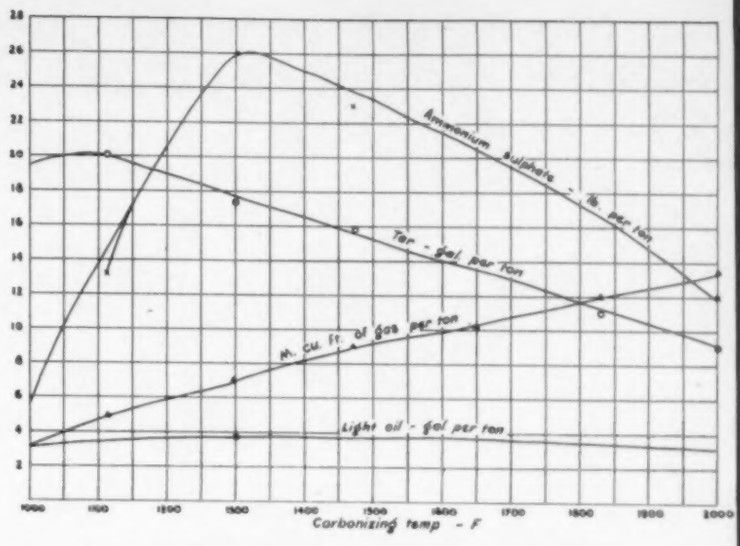


Figure 38 — Curves showing effect of carbonizing temperature on yields of ammonium sulphate, tar, gas, and light oil.

The total Btu in the gas from one pound of coal may run 2800 to 3400, increasing with the volatile content of the coal and with temperature of carbonization. The average seems to be satisfied by the equation:

$$\text{Btu in gas per lb of coal} = 2135 + 29.5\ V$$

where V = per cent volatile in the coal.

More than 3400 Btu in the gas from a pound of coal indicates excessive degradation of tar vapors by high temperatures.

Calorific value of the gas also varies with the volatile content of the coal, as does the specific gravity, but these items are so dependent on other factors that calculations are impractical.

There are also sulphur compounds (hydrogen sulphide, carbon disulphide, etc.) in the gas, varying from one to six grains per cu ft, depending on the amount and character of sulphur in the coal. Sulphur in the gas is usually reported in grains of hydrogen sulphide per 100 cu ft of gas. Results of a series of tests show the gas carrying a range of 100 to 389 grains of H_2S for one per cent of sulphur in the coal. General practice, however, indicates that 62 per cent of the sulphur in the coal goes into the coke, the remainder appearing prin-

TABLE XI

PROPERTIES OF IMPORTANT CONSTITUENTS OF LIGHT OILS

	Benzene	Toluene	Xylene	Naphthalene
Formula	C_6H_6	C_7H_8	C_8H_{10}	$C_{10}H_8$
Molecular weight	78	92	106	128
Specific gravity, 62 F	0.8679	0.8573	0.8574	1.15
Boiling point (atmosphere), F	176	230	282	422
Increase in boiling point, degrees F per in. Hg	0.61	0.66	0.74	0.83
Lb per cu ft vapor (60 F, 30 in. Hg)	0.209	0.244	0.281	0.339
Btu per lb of liquid	17,930	18,270	18,410	17,460
Btu per gal of liquid	132,100	132,600	133,500	167,300
Btu per cu ft of vapor	3,780	4,500	5,210	5,910
Specific heat	0.419	0.44	0.383	0.314
Heat of vaporization, Btu per lb	167	150	140	.....

TABLE XII

AVERAGE RECEIPTS (CENTS PER UNIT) OF BY-PRODUCTS SOLD

Year	Tar (gal)	Ammonia (lb)		Surplus gas (M cu ft)	Benzol (gal)		Toluol, crude and refined (gal)	Solvent naphtha (gal)	Xylol, crude and refined (gal)	Crude naphthalene (lb)
		Sulphate	Liquor		Motor	All other grades				
1919	3.2	3.8	11.0	8.6	17.6	20.6	26.3	15.2	.....	2.0
1924	4.6	2.4	9.8	16.5	15.2	21.1	23.8	18.7	.....	1.5
1929	5.1	1.8	5.1	16.6	15.9	21.1	38.6	24.2	.....	1.6
1934	3.9	1.0	2.9	19.1	9.4	15.7	27.5	17.4	23.0	1.3
1939	4.8	1.1	3.1	16.6	9.2	13.2	19.4	17.0	23.2	1.6
1940	4.6	1.2	3.2	15.5	8.4	12.7	24.2	15.9	23.2	1.7
1941	4.7	1.3	3.3	15.3	7.6	11.6	24.2	15.1	23.7	1.8
1942	5.4	1.3	3.5	15.2	8.6	13.0	26.5	14.3	25.0	2.0
1943	5.4	1.3	3.7	15.0	9.0	13.0	26.9	14.8	24.9	2.1
1944	5.4	1.3	3.2	15.2	8.9	13.1	27.1	14.7	25.7	2.0
1945	5.3	1.3	3.0	15.8	8.6	13.0	26.3	14.4	25.8	2.1
1946	5.6	1.4	3.0	17.3	8.8	12.9	20.5	12.9	22.7	2.2

cipally in the gas. This relationship may be approximated by a straight line expressed by the formula:

Grains H_2S per 100 cu ft of gas = 325 (S—0.15)

Where S = per cent sulphur in the coal.

Tar is a black, rather thick and viscous liquid at ordinary temperatures, with a specific gravity of 1.15 to 1.21. It usually becomes semi-solid at about 30 F. Tar is a very complex mixture, containing some 300 compounds. In its crude state it is used as fuel and for road dressing, but by refining it is made to yield many important products.

Fractionation of tar is not usually practiced in American steel plants, but a typical tar refines somewhat as follows:

	Per cent
Water	1.25
Light oil (221-338 F)	1.20
Carbolic oil (338-445 F)	9.48
Creosote oil (445-517 F)	10.08
Anthracene oil (517-660 F)	21.71
Pitch (at 660 F)	56.28
	100.00

Each of these fractions may then be further rectified for the production of many products.

The yield of tar is influenced by the rank and grade of the coal used. Low and medium volatile coals give low yields, as do coals high in oxygen. When tar yields are plotted against the percentage of volatile matter in the coal, the points do not fall into any definite linear relation. However, an average relationship can be expressed as follows:

Gal of tar per ton of coal = 0.51 (V—10.5)

where V = per cent volatile matter in coal as carbonized.

Values from this equation can be made more accurate by subtracting or adding ½ gallon for each per cent of oxygen in the coal above or below 8.

The yield of tar for a given coal drops as carbonizing temperature is increased. Hot or empty oven tops also decrease tar yields, due to tar vapors cracking up. Increasing oven temperatures also changes the composition of tar, the naphtha, creosote and anthracene contents dropping, and the pitch content rising, while specific gravity also increases. The presence of steam during carbonization tends to increase tar yield.

Tar yields may range from 7 to 12 gal per net ton of coal coked. The present national average is 7.82 gal.

Tar weighs 9.6 to 10.0 lb per gal, and has a calorific value of 155,000 to 165,000 Btu per gal. It requires 4.8 Btu to raise one gallon one degree F.

Ammonia represents only 0.2 to 0.4 per cent by weight of the coal, but it is commercially important. Concentrated ammonia liquor is used in making many ammonium salts, in dye works, and in many manufacturing operations. Ammonium sulphate is used primarily as fertilizer, but has also some use in the production of certain chemicals.

There seems to be no consistent variation of ammonia yield with the rank of the coal carbonized. Ammonia liquor recovery is somewhat proportional to the oxygen in the coal, ranging 58 to 104 per cent of the total weight of oxygen in the coal as carbonized. Ammonia yield seems to vary with the nitrogen content of the coal, but not in proportion, 18 to 30 per cent of the nitrogen appearing in the ammonia.

Ammonia yields are increased by moisture, by comparatively cool oven tops, by the avoidance of too rapid coking rates with attendant high temperatures, by uniform heating and by minimum vacant space in oven tops. High-volatile coals usually produce more ammonia than low-volatile coals.

The ammonia liquor recovered may range 12 to 20 gal per net ton of coal coked. If this is turned into ammonium sulphate with the ammonia carried on by the gas, as much as 26 lb of ammonium sulphate may be produced per net ton of coal coked. The overall average is about 19.8 lb per ton of coal.

Light oil in its crude state has a composition approximately as follows:

	Per cent
Pure benzene	56
Pure toluene	16
Xylenes and light solvent naphtha	9
Heavy hydrocarbons and naphtholene	8
Wash oil	6
Acid washing loss	5
	100

Table XI gives properties of the important constituents of light oil.

Crude light oil has a specific gravity of 0.85 to 0.88, and weighs 7.0 to 7.3 lb per gal. It has a calorific value

TABLE XIII

YIELDS AND ANALYSES OF PRODUCTS OF CARBONIZATION PROCESS

Product	Constituent	Per cent of coal by weight	Analysis per cent of product by weight	Yield lb per net ton of coal
Coke	Ash	7.210	10.24	144.20
	Carbon	61.711	87.76	1234.22
	Hydrogen	0.469	0.66	9.38
	Sulphur	0.683	0.96	13.66
	Nitrogen	0.270	0.38	5.40
	Totals	70.343	100.00	1406.86
Gas	CO_2	1.042	6.66	20.84
	CO	3.154	20.14	63.08
	CH_4	7.468	47.69	149.36
	C_2H_4	1.529	9.76	30.58
	N_2	0.385	2.46	7.70
	H_2	1.366	8.72	27.32
	O_2	0.717	4.57	14.34
	Totals	15.661	100.00	313.22
Ammonia	Hydrogen	0.040	17.9	0.80
	Nitrogen	0.183	82.1	3.66
	Totals	0.223	100.0	4.46
Tar	Carbon	4.687	86.0	93.74
	Hydrogen	0.327	6.0	6.54
	Oxygen	0.436	8.0	8.72
	Totals	5.450	100.0	109.00
Liquor	Moisture	3.310	48.70	66.20
	Oxygen	3.107	45.60	62.14
	Hydrogen	0.388	5.70	7.76
	Totals	6.805	100.00	136.10
Light oils	C_6H_6 (Equivalent)	1.102	100.00	22.04
Cyanogen	C_2N_2	0.078	100.00	1.56
Carbon disulphide	CS_2	0.013	100.00	0.26
Hydrogen sulphide	H_2S	0.325	100.00	6.50

of 145,000 Btu per gal, and 3.6 Btu are required to heat one gallon one degree F.

The yield of light oils shows a direct proportionality to the volatile content of the coal, which is approximated by the formula:

Gal of light oil per ton of coal = 0.14 (V—8.5).

For a given coal, light oil yield increases with temperature of carbonization up to 1650 F, beyond which the yield drops. The composition of the light oil also changes the percentage of benzene increasing with temperature, while the percentage of toluene increases to a maximum at 1475 F, and then drops.

Efficiency of recovery, which depends on many factors of plant construction condition and operation, may seriously affect light oil yield, so that any prediction of yield based on coal quality alone must be used with care.

Benzols are widely used as solvents for fats, waxes, gums and resins, and hence has many applications in the manufacture of cleansers, paints, insulating varnishes, waterproofing materials, plastics and synthetic rubber. Pure benzol is the base from which many drugs, insecticides, dye stuffs and explosives are made.

Toluol is used in the rubber and paint industries, and in the manufacture of the explosive TNT. Pure toluol is the base from which saccharin, many dye stuffs and perfumes are prepared.

Naphthalene is used as an antiseptic and insecticide, and it is the base from which many dye stuffs are prepared. It is also used in the preparation of sulfa drugs and the manufacture of plastics.

A material balance, showing the distribution of the elements in the coal during the coking process, is shown in Tables XIII and XIV for a coal of the following analysis:

Approximate analysis	Per cent
Moisture	3.31
Volatile matter	34.21
Fixed carbon	54.85
Ash	7.63
	100.00

Ultimate analysis	
Moisture	3.31
Carbon	76.00
Hydrogen	4.78
Oxygen	6.82
Nitrogen	0.88
Sulphur	1.00
Ash	7.21
	100.00

TABLE XIV

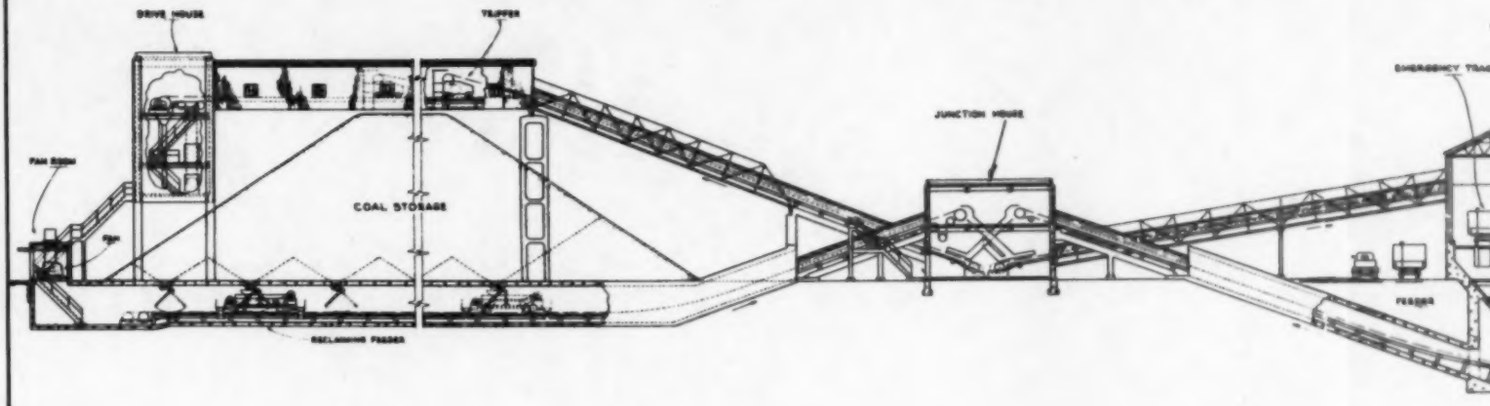
DISTRIBUTION OF ELEMENTS IN CARBONIZATION PROCESS

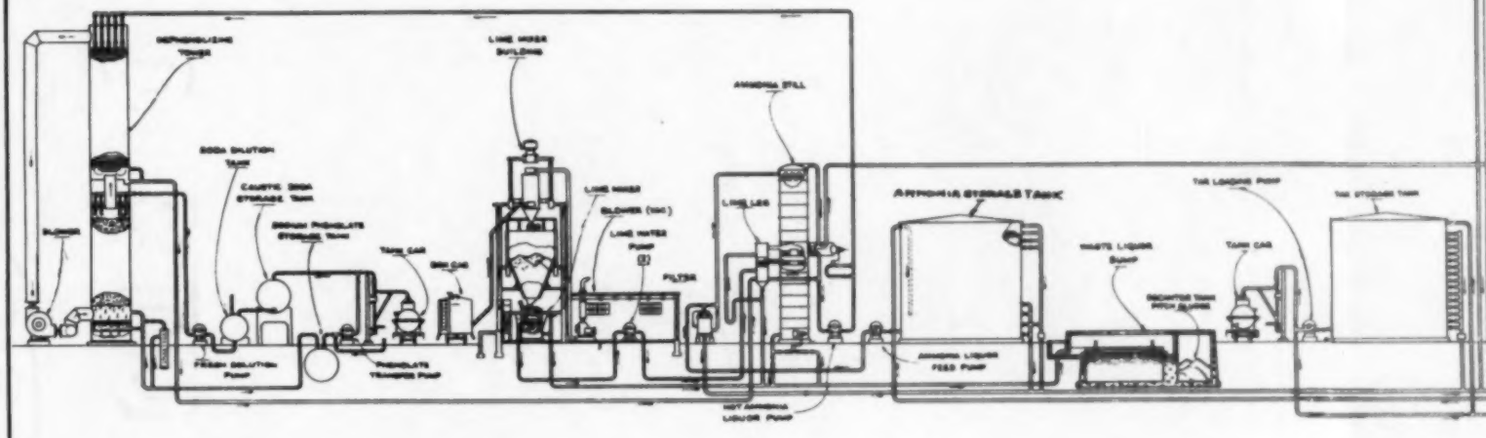
Element	Per cent of coal by weight	Physical state	Product	Per cent of coal	Sub-total per cent of coal	Total per cent of coal
Moisture	3.31	Liquid	Ammonia liquor	.....	.....	3.31
Ash	7.21	Solid	Ash	.....	.....	7.21
Carbon	76.00	Solid	Coke Retort carbon	61.611 0.1	61.711	61.711
		Liquid	Tar	.....	.....	4.687
		Gas	CO_2 CO CH_4 C_2H_4	0.284 1.352 5.601 1.311	8.548	9.602
		Vapor	C_6H_6 C_2N_2 CS_2	1.016 0.036 0.002	1.054	
Hydrogen	4.78	Liquid	Ammonia liquor Tar	0.388 0.327	0.715	0.715
		Gas	H_2 CH_4 C_2H_4	1.366 1.867 0.218	3.451	3.596
		Vapor	Benzol NH_3 H_2S	0.086 0.040 0.019	0.145	.....
Oxygen	6.82	Liquid	Tar Ammonia liquor	0.436 3.107	3.543	3.543
		Gas	CO_2 CO	0.758 1.802	2.560	3.277
		Vapor	Vapors	0.717	0.717	
Nitrogen	0.88	Solid	Coke	.....	.....	0.270
		Gas	N_2	0.385	0.385	0.610
		Vapor	NH_3 C_2N_2	0.183 0.042	0.225	
Sulphur	1.00	Solid	Coke	.....	.....	0.683
		Vapor	H_2S CS_2	0.306 0.011	0.317	0.317
Total	100.00	.....	.....	.....	.....	99.531

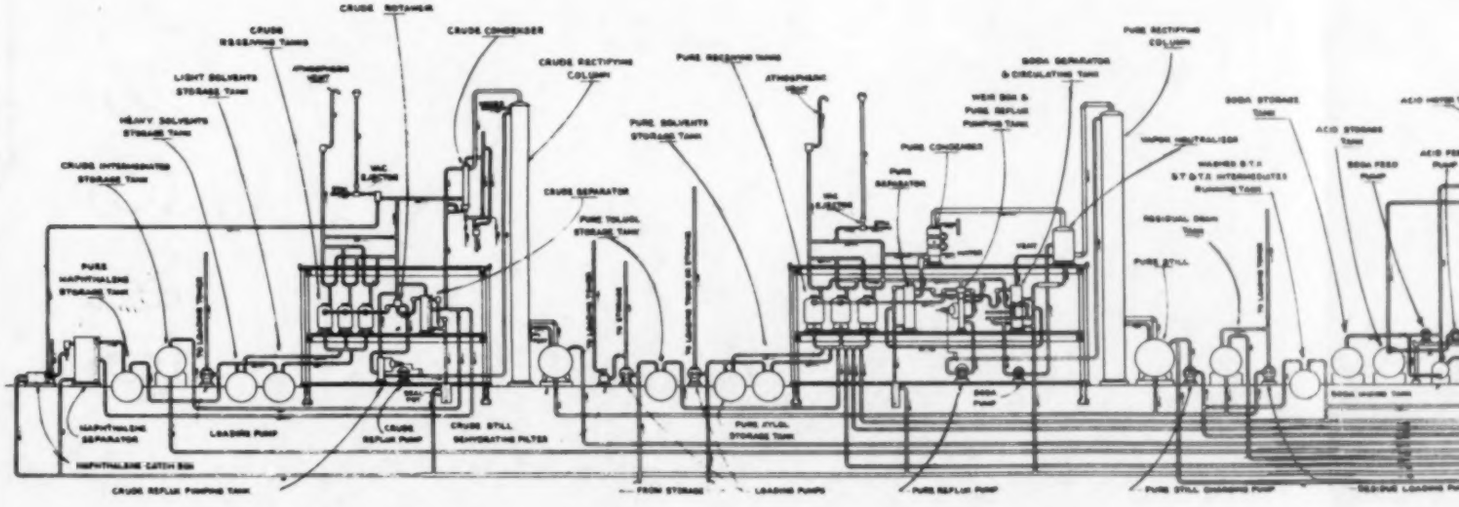
UTILITY REQUIREMENTS

Steam requirements of a coke plant will vary widely with the nature and equipment of the plant. In a typical plant coking about 3100 tons of coal per day, steam consumption (200 psi gage, 100 F super heat) is somewhat as follows:

Live steam requirements	Pounds per hr Normal	Maximum
Ascension pipes	300	300
Fuel gas heaters	240	240
Liquor circulating pump	6,000	6,000
Liquor flushing pump	Motor	4,800
Pitch sludge tank		400
Pitch sludge pump		
Pitch feed tank		
Tar collecting tanks	260	370
Tar transfer pump	400	400
Condensate drain pump	700	700
Exhausters	17,010	17,010
Fuel gas holder		950
Surplus gas boosters	11,450	11,450
Ammonia still — agitation	450	450
Tar circulating pumps	1,100	1,100
Wash oil pumps	2,080	2,080
Final heater	5,500	5,500
Wash oil purifier	150	160
Light oil rectifier	600	600
Muck tank		200
Carbon disulphide reboiler	1,300	1,360
Motor fuel reboiler	1,750	1,820
Pure still tank	2,970	3,080
Crude still tank	580	630
Soda circulating tank — agitation		
Receiver tank ejectors	240	240
Charging pumps	500	540
Benzol loading pumps		
General service pump		
Dephenolizing tower	2,200	2,340







CRUDE PRODUCTS PLANT

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PROCESSES IN A M
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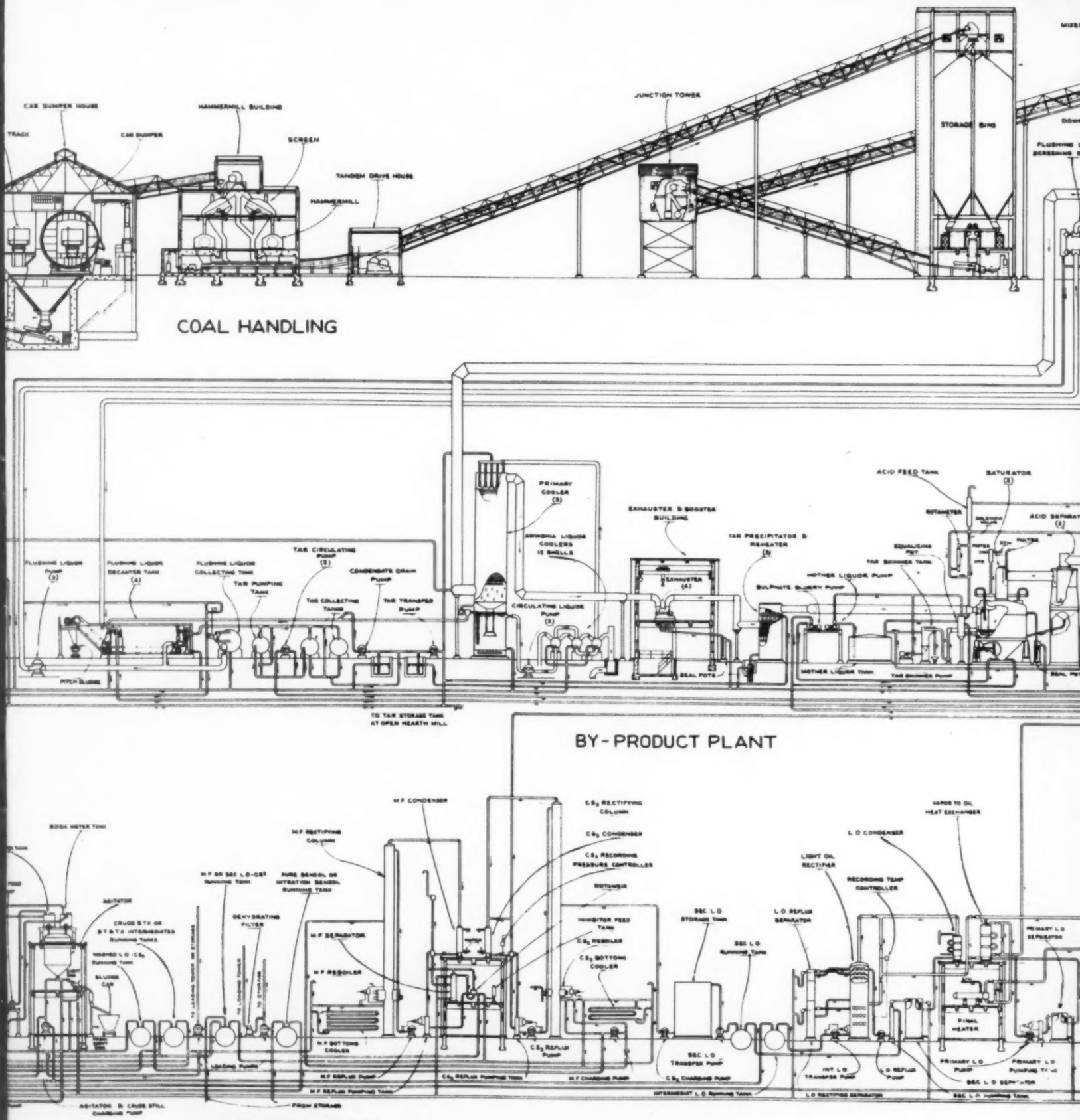

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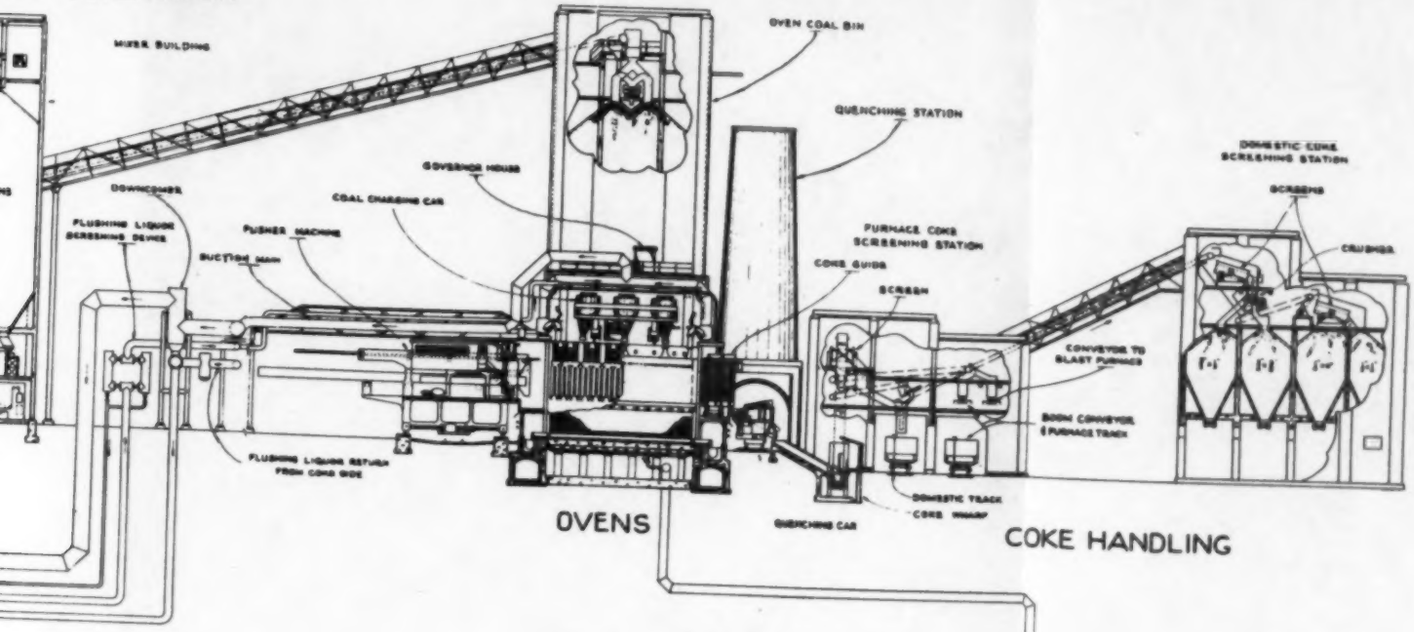

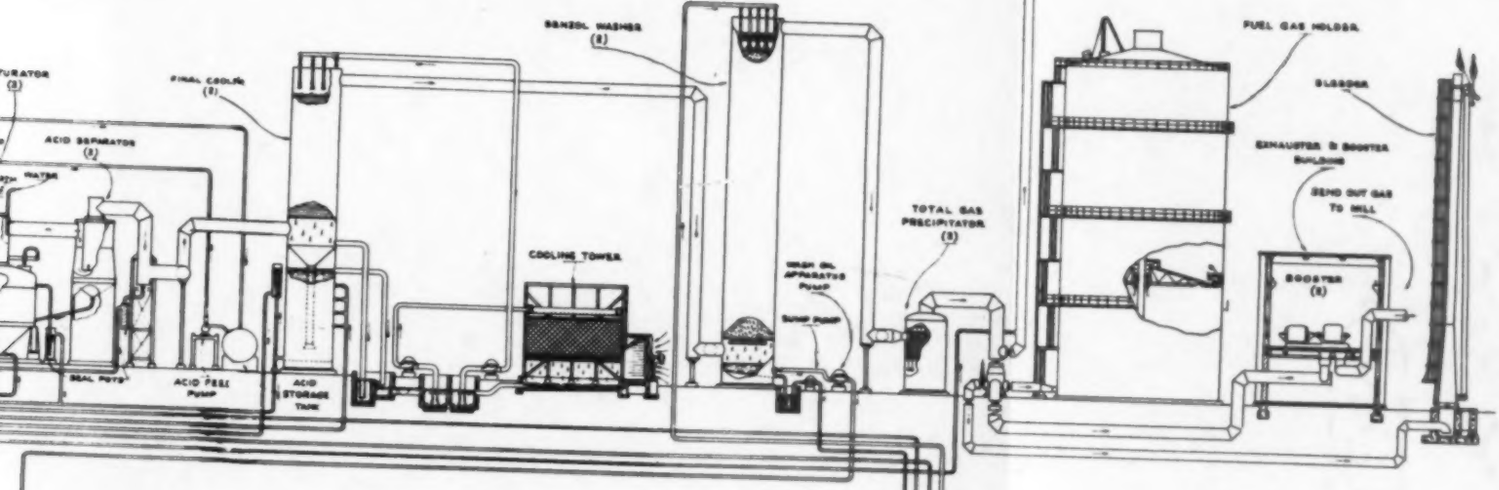

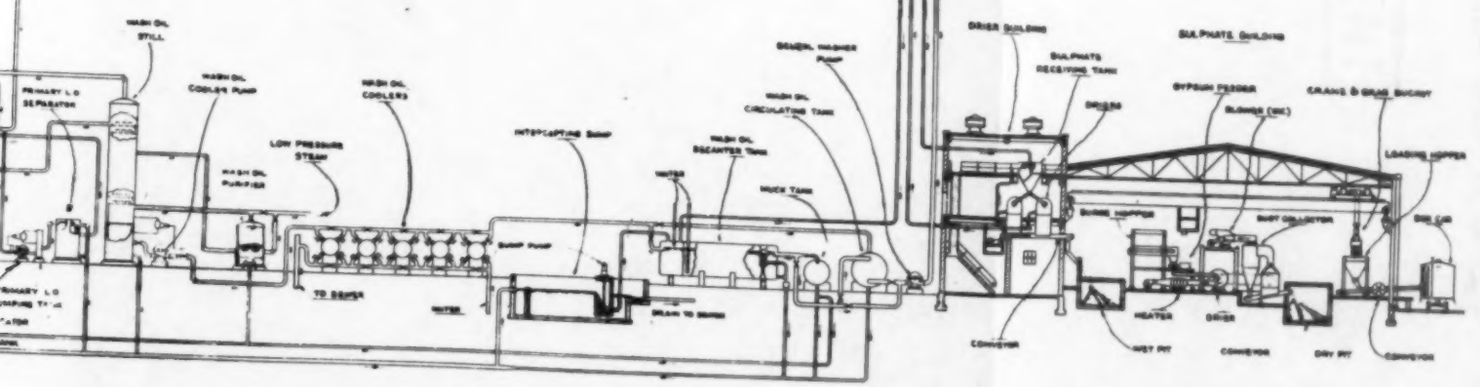

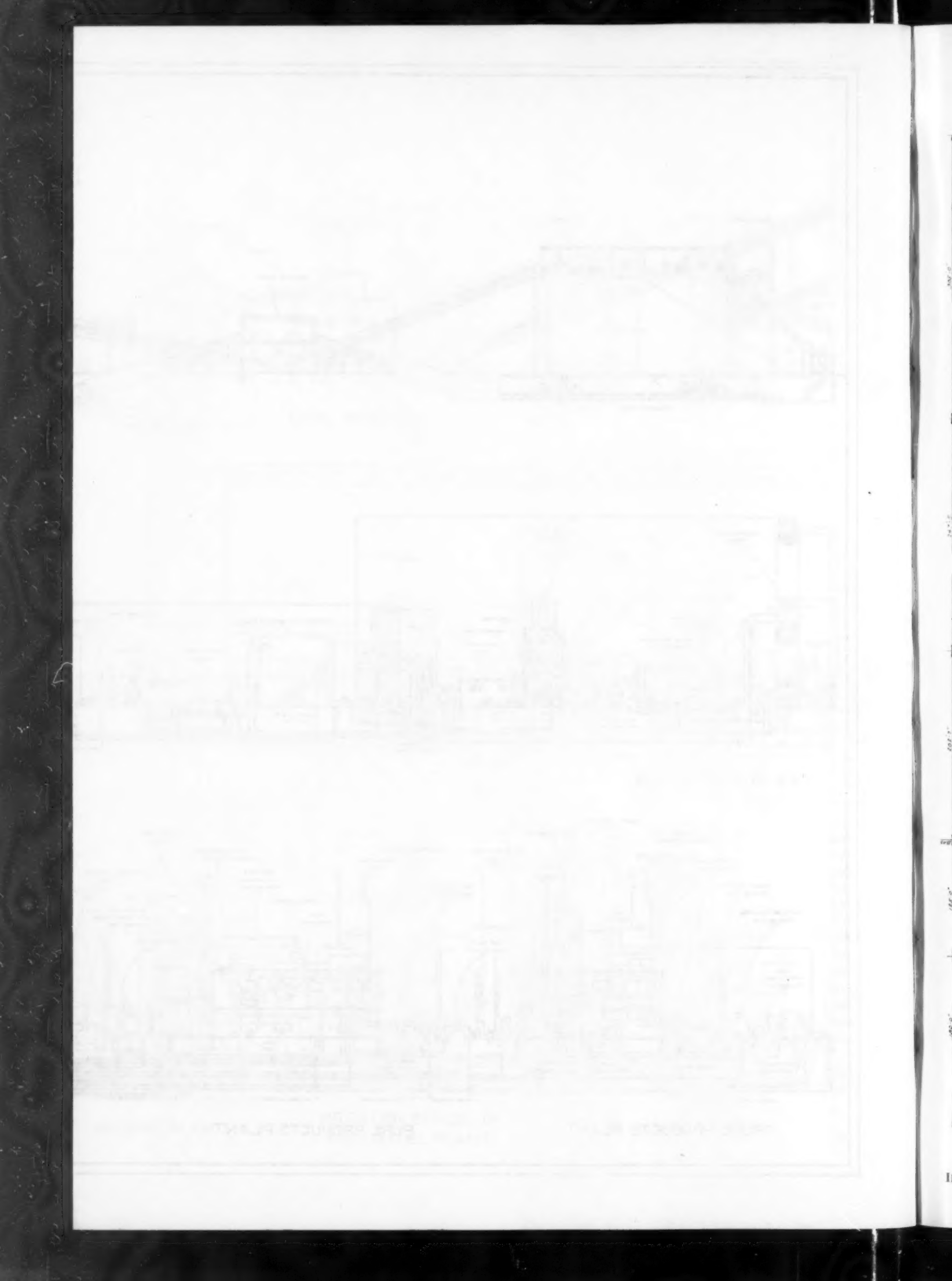

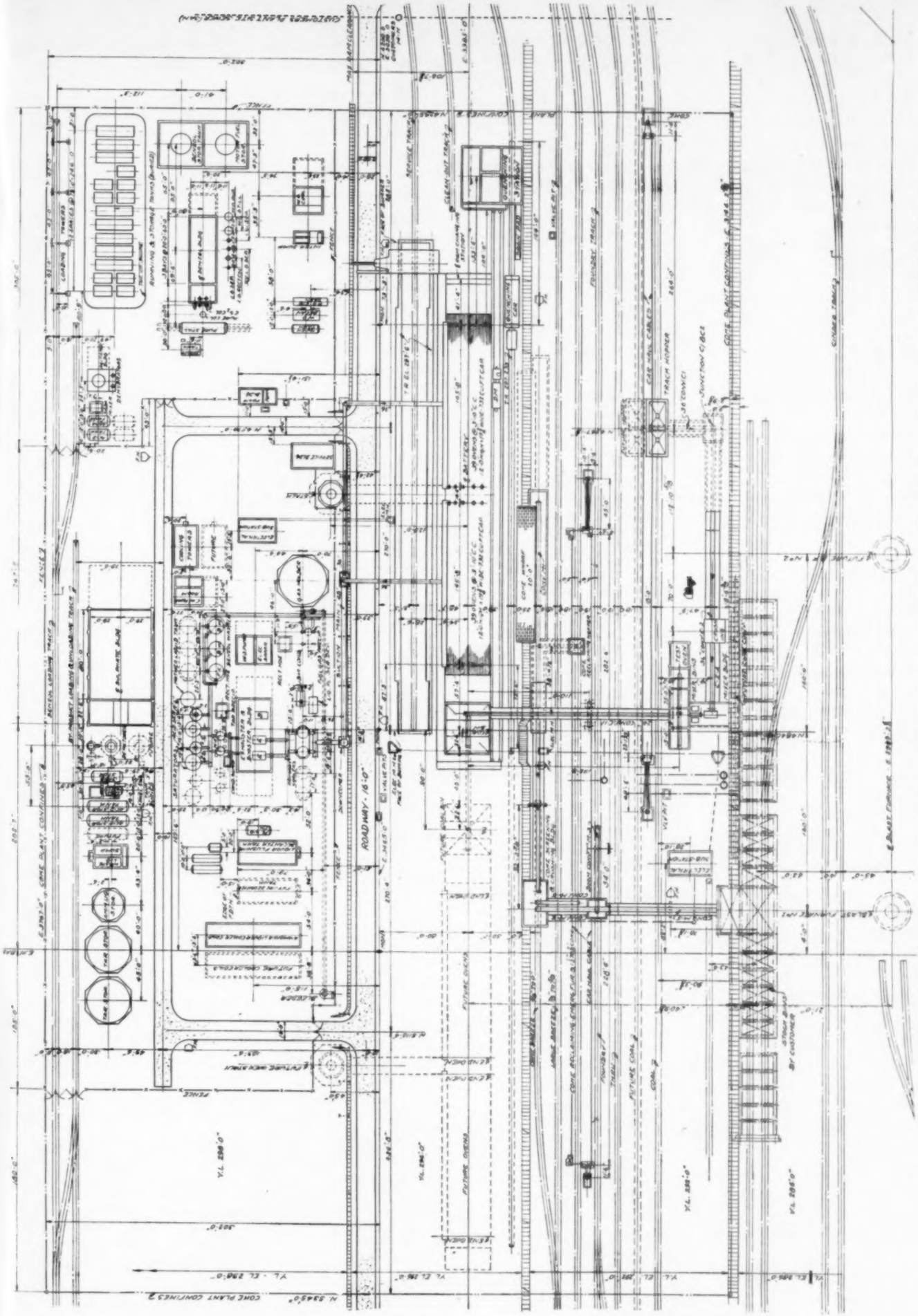

Figure 39 — Layout of a single battery plant consisting of 78 under-jet ovens with complete facilities for by-product and light oil recovery.

Vacuum pump	200	200
Live make-up	1,540	1,880
Total required	57,520	64,800
Lb per ton coal	442	499

Of the above usages, seven items operate against a back pressure of about 15 psi, furnishing exhaust steam for various heating operations. Steam flows to this low-pressure system from the following units:

	Pounds per hr	
	Normal	Maximum
Exhausters	17,010	17,010
Liquor circulating pumps	6,000	6,000
Liquor flushing pumps	Motor	4,800
Tar transfer pump	400	400
Condensate drain pump	700	700
Wash oil pump	2,080	2,080
Tar circulating pump	1,100	1,100
Total exhaust steam supply	27,290	32,090
Less condensation	2,730	3,210
Exhaust steam available for use	24,560	28,880

The low-pressure steam is used in the following units:

	Pounds per hr	
	Normal	Maximum
Ammonia still	7,800	8,300
Reheater	1,470	1,470
Tar storage tanks	2,000	3,000
Water heater	530	720
Heating buildings		1,000
Tar pumping tank		20
Wash oil still	14,300	15,000
Benzol plant tanks		850
Phenol plant tanks		400
Total low-pressure steam required	26,100	30,760
Difference to be supplied from live steam system	1,540	1,880

Consumption by the exhauster and booster will vary somewhat with the amount of gas passing through. Steam consumption of the light oil stills will vary with the product being made, running higher when producing the heavier products. Heating of tanks and buildings will of course vary with atmospheric temperature. In existing plants, steam consumption figures may be found showing 250-800 lb of steam per ton of coal.

Electric power consumption also varies with the type of equipment, but for a typical single-battery plant carbonizing about 1200 tons of coal per day, average consumption will run somewhat as follows:

	Average kw	
	a-c	d-c
Ovens (including coal handling)	100	30
By-product plant	100	5
Benzol plant (including gas purification)	145	..
	345	35

This amounts to 7.1 kwhr per ton of coal coked. This value may vary from 6 to 12 kwhr per ton of coal.

Water pumping may use 3 to 5 kwhr per ton of coal coked in addition to the above figures.

Complete by-product coke plants contain 1 or 2 motors per oven, and range 20 to 40 connected hp per oven, these values decreasing as the size of the plant increases.

The ratio of average kw consumption to connected hp runs 23 to 28 per cent.

Water consumption may run from 2000 to 4000 gallons per ton of coal coked in a single-battery plant as given above.

Items entering this are:	Gpm
By-product plant	300-600
Benzol plant	300-700
Wash oil cooler	Up to 1000
Liquor cooler	500-800
Battery	200
Pump house	120-200

Water for quenching is sprayed at a rate of 6000 to 10,000 gpm for 45 to 60 seconds. Between 15 and 20 per cent of this water is evaporated and carried out by the coke. The remainder is recirculated.

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APPENDIX

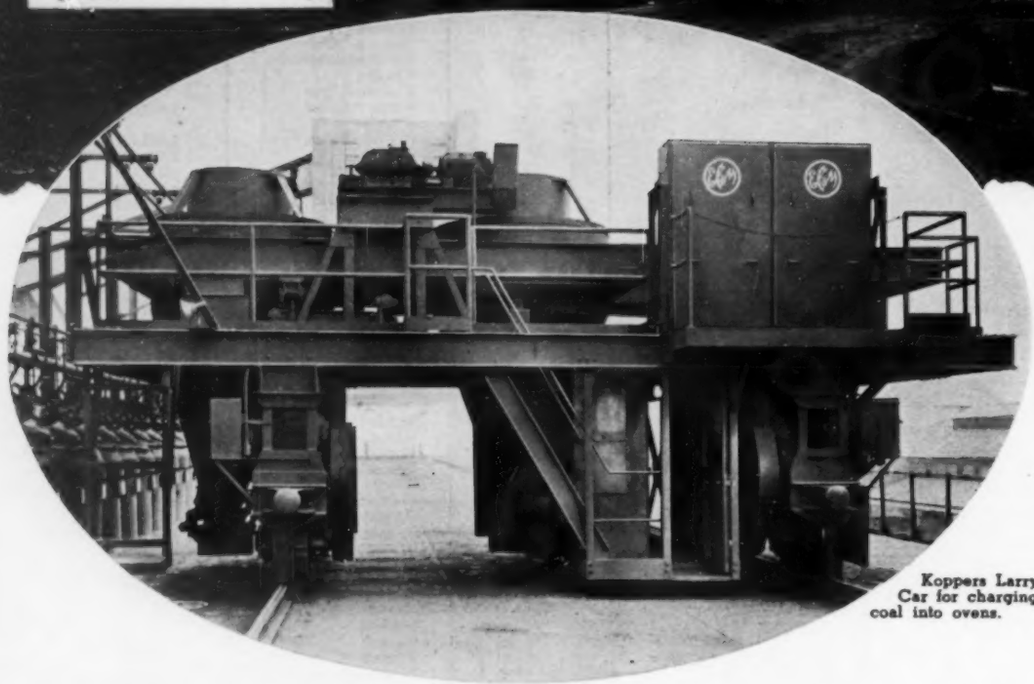
TABULATION OF COKE PLANTS IN THE STEEL INDUSTRY

Company	Location	Ovens		Estimated annual coke capacity, net tons
		Number	Type	
Alan Wood Steel Company	Swedeland, Pa.	110	Koppers	600,000
		41	Becker	
American Rolling Mill Company	Hamilton, Ohio	110	Koppers-Becker	670,000
American Steel and Wire Company	Cleveland, Ohio	180	Koppers	874,000
	Duluth, Minn.	90	Koppers	435,000
Bethlehem Steel Company	Bethlehem, Pa.	212	Koppers	1,880,000
		204	Koppers-Becker	
	Steelton, Pa.	60	Koppers	648,000
		70	Koppers-Becker	
	Sparrows Point, Md.	300	Koppers	2,430,000
		183	Koppers-Becker	
	Lackawanna, N. Y.	60(1)	Semet-Solvay	
		171	Koppers-Becker	2,022,000
		152	Wilputte	
	Johnstown, Pa.	120	Cambria	
		88	Semet-Solvay	1,884,000
		154	Koppers-Becker	
		74(2)	Wilputte	400,000
Carnegie-Illinois Steel Corporation	Clairton, Pa.	768	Koppers	7,457,000
		714(3)	Koppers-Becker	
		85(2)	Koppers	365,000
	Gary, Ind.	416	Koppers-Becker	
		357	Wilputte	5,676,600
		280	Koppers	
		77(2)	Wilputte	414,000
	Joliet, Ill.	280	Koppers	1,272,000
Colorado Fuel and Iron Corporation	Pueblo, Colo.	120	Koppers	935,000
		146	Koppers-Becker	
Columbia Steel Company	Provo, Utah	56	Koppers	209,500
Crucible Steel Company of America	Midland, Pa.	100	Koppers	575,000
		21	Koppers-Becker	
		63(2)	Koppers-Becker	280,000
Donner-Hanna Coke Corporation	Buffalo, N. Y.	150	Koppers	1,200,000
		66	Koppers-Becker	
Eastern Gas and Fuel Associates	Boston, Mass.	149	Koppers-Becker	1,112,000
		55	Wilputte	
Ford Motor Company	Dearborn, Mich.	183	Koppers-Becker	1,260,000
H. C. Frick Coke Company	Pennsylvania	2918	Beehive	2,078,750
Geneva Steel Company	Geneva, Utah	252	Koppers-Becker	971,000
		500	Beehive	300,000
Great Lakes Steel Corporation	Detroit, Mich.	130	Semet-Solvay	996,600
Inland Steel Company	Indiana Harbor, Ind.	68	Koppers	2,143,400
		353	Koppers-Becker	
Interlake Iron Corporation	Chicago, Ill.	120	Semet-Solvay	370,000
	Erie, Pa.	72	Wilputte	265,000
	Toledo, Ohio	94	Koppers	365,800
	Duluth, Minn.	41	Becker	225,600
International Harvester Company	Chicago, Ill.	45	Koppers-Becker	600,000
		88	Wilputte	
Jones and Laughlin Steel Corporation	Aliquippa, Pa.	248	Koppers-Becker	1,476,000
		240	Beehive	
		106(2)	Koppers-Becker	710,000
	Pittsburgh, Pa.	300	Koppers	1,596,000
		60	Wilputte	
	Cleveland, Ohio	100	Semet-Solvay	360,000
Kaiser Company, Inc.	Fontana, Calif.	90	Koppers-Becker	340,000
Koppers Company, Inc.	Granite City, Ill.	49	Koppers-Becker	435,000
Lone Star Steel Company	Daingerfield, Tex.	78	Koppers-Becker	375,000
National Tube Company	Lorain, Ohio	206	Koppers	1,903,200
		177	Wilputte	
Pittsburgh Coke and Chemical Company	Neville Island, Pa.	70	Koppers-Becker	500,000
Pittsburgh Steel Company	Republic, Pa.	510	Beehive	420,000
	Monessen, Pa.	74	Koppers-Becker	500,000
Portsmouth Steel Corporation	Portsmouth, Ohio	108	Semet-Solvay	475,000
Republic Steel Corporation	Youngstown, Ohio	100	Koppers	1,070,000
		112	Koppers-Becker	
	Warren, Ohio	64	Koppers-Becker	695,000
		61	Wilputte	
		80(4)	Koppers	506,000
	Canton, Ohio	62	Koppers	255,000
	Massillon, Ohio	49	Koppers-Becker	295,000
	Cleveland, Ohio	204	Koppers	1,280,000
		75	Koppers-Becker	
	Brownsville, Pa.	296	Beehive	215,000
	Chicago, Ill.	75	Wilputte	405,000
	Gadsden, Ala.	37	Koppers	493,000
		65	Wilputte	
	Birmingham, Ala.	57	Koppers-Becker	370,000
Sharon Steel Corporation	Morgantown, W. Va.	74	Wilputte	415,000
Sheffield Steel of Texas	Houston, Tex.	47	Koppers	252,000
Sloss-Sheffield Steel and Iron Company	Lewisburg, Ala.	94	Beehive	60,600
		120	Semet-Solvay	678,000
Tennessee Coal, Iron and Railroad Company	Fairfield, Ala.	418	Koppers-Becker	3,160,000
		154	Koppers	
Tennessee Products Corporation	Chattanooga, Tenn.	24	Semet-Solvay	268,000
		20	Wilputte	
Weirton Steel Company	Isabella, Pa.	136	Beehive	120,000
	Weirton, W. Va.	262	Koppers-Becker	1,550,000
Wheeling Steel Corporation	East Steubenville, W. Va.	94	Koppers	700,000
		51	Koppers-Becker	
		106(2)	Koppers-Becker	710,000
Woodward Iron Company	Woodward, Ala.	60	Wilputte	885,490
		170	Koppers	
Youngstown Sheet and Tube Company	Campbell, Ohio	306	Koppers	1,320,000
	Youngstown, Ohio	84	Koppers	372,000
	East Chicago, Ind.	120	Semet-Solvay	648,000
	Chicago, Ill.	70	Koppers-Becker	444,000

(1) Being rebuilt by Wilputte.
(2) Under construction.
(3) 61 of these ovens being rebuilt.
(4) Under construction. To replace 64 Koppers-Becker ovens.

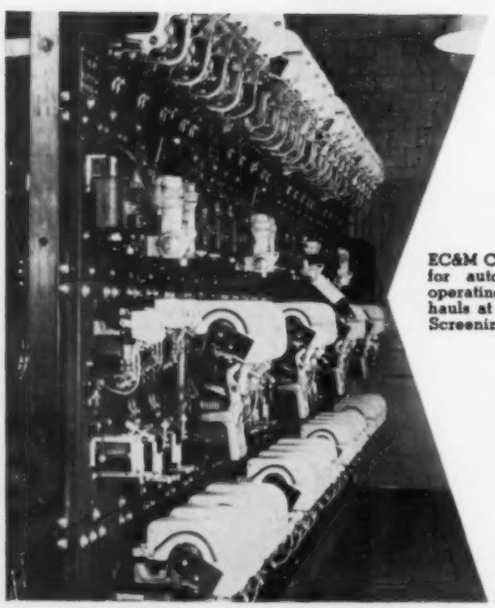
EC&M Control Improves Operation of Coke Oven Machines

Coke Pusher built by Wellman Engineering Company, for the Wilputte Coke Oven Division. Door machine is in left foreground.



Koppers Larry Car for charging coal into ovens.

Here's How



EC&M Controllers for automatically operating four car-hauls at the Coke Screening Station

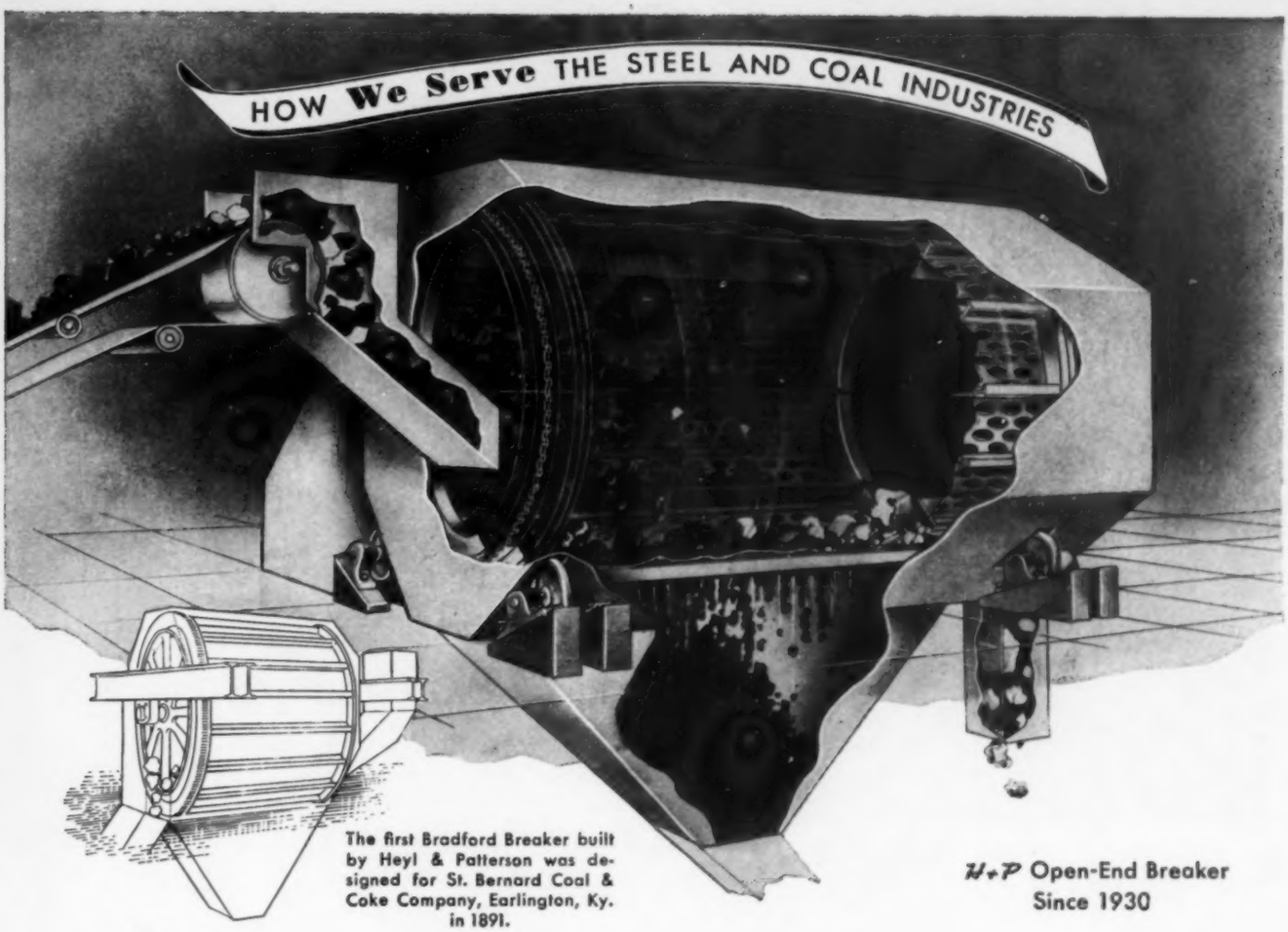
1. Controllers using EC&M LINE-ARC Magnetic Contactors have long contact-life, due to cool contact operation. And there is no destructive arc-shield burning.
2. These coke machines accelerate quickly and smoothly under the EC&M TIME-CURRENT Method of Acceleration—this is a proven system giving fast, safe performance. There's only one adjustable relay for plugging, too.
3. Equipment of sound basic design applied by accurate engineering results in excellent operation of the machines from the first operation throughout their entire life.

The buyers of the machines, here illustrated, selected EC&M Control. You, too, can benefit when buying new machines or revamping existing installations, by specifying EC&M Control, Brakes and Limit Switches.

EC&M's Fiftieth Anniversary

THE ELECTRIC CONTROLLER & MFG. CO.

2698 East 79th Street **Cleveland 4, Ohio**



The first Bradford Breaker built by Heyl & Patterson was designed for St. Bernard Coal & Coke Company, Earlington, Ky. in 1891.

H+P Open-End Breaker Since 1930

We DESIGN, BUILD & ERECT

BRADFORD BREAKERS

Through the years since 1891, H+P has continued to build the standard type of Bradford Breaker.

These Bradford Breakers remove rock and other foreign materials from the coal and also reduce the coal to the required size. It is essentially a preliminary coal cleaner. At the same time it functions as a crusher and as protection to coke plant or power plant equipment which may follow it.

In 1930 H+P built their first open-end Bradford Breaker, which permits entry of larger pieces into the breaker.

H+P open-end breakers are being used where full seam mechanized mining produces a larger percentage of refuse as well as larger pieces of rock. The Coal Preparation Plant is thus relieved of handling this foreign material. New improvements by H+P allow for screening the coal with a minimum of degradation.

Ore Bridges
Railroad Car Dumpers
High Lift-Turnover-Rotary
Boat Loaders & Unloaders
Car Hauls & Boat Movers
Bradford Breakers
Coal & Coke Handling Equipment
Pig Iron Casting Machines
Coal Preparation Plants
Rotary Mine Car Dumpers
Coal Crushers
Refuse Disposal Cars
Coal Storage Bridges

Heyl+Patterson, Inc.

"SINCE 1887"

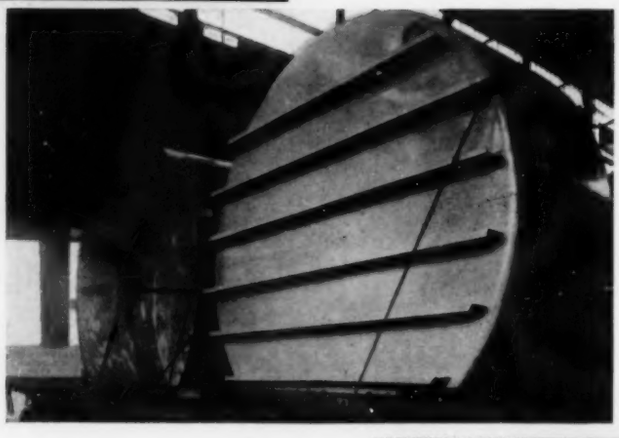
55 WATER STREET · PITTSBURGH 22, PA.

TREADWELL

REDUCE MAINTENANCE COST BY USING

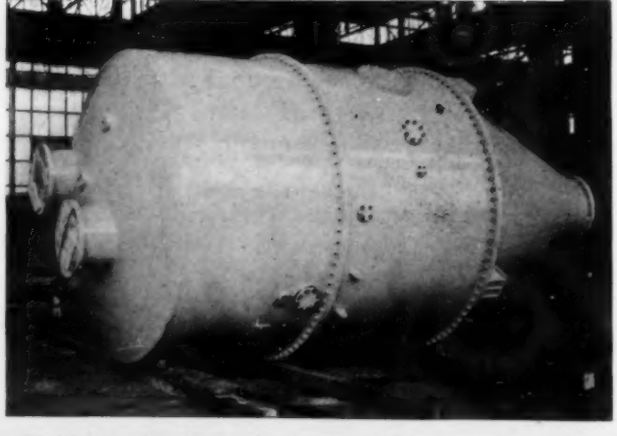
HOMOGENEOUS LEAD LINED
TANK CARS
FOR TRANSPORTATION OF
CORROSIVE LIQUIDS
OVER
I.C.C. CONTROLLED TRACKAGE
3,600 TO 10,000 GAL. CAP.

HOMO-
GENEOUS
LEAD
LINED
TANKS
for



ACID
RECOVERY
STRIP
PICKLING
STRIP
STEEL
COATING

HOMOGENEOUS LEAD LINED
PROCESSING EQUIPMENT
FOR
PYRIDINE MANUFACTURE
AND
OTHER COKE PLANT
BY-PRODUCTS



TREADWELL CONSTRUCTION CO.

SALES OFFICES

1217 FARMERS BANK BLDG.
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208 LA SALLE ST.
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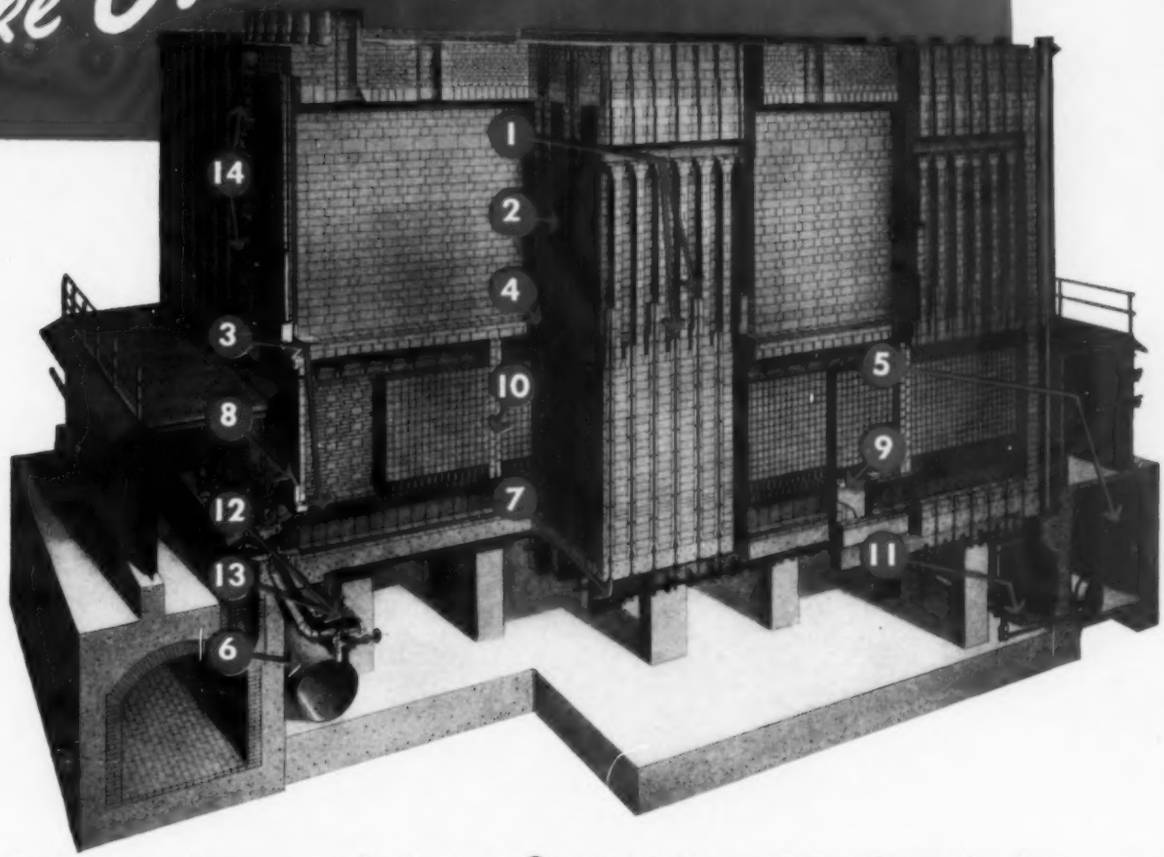
Some of the Reasons

why WILPUTTE Coke Ovens are Superior



1. Alternating high and low burners—*vertical uniformity in rich gas heating.*
2. Walls of unstepped thickness—*vertical uniformity in heating with lean gas.*
3. Venturi ports—*air, lean gas, and waste gases distributed uniformly through regenerators.*
4. Graduated air ports—*built-in regulation of air and lean gas.*
5. Combustion air system—*accurate control of combustion air, uniform ventilation of basement.*
6. Orifice and butterfly—*lean gas at equal flow to each regenerator.*
7. Stainless steel pins—*precision distribution of rich gas to the burners, readily accessible for cleaning.*
8. Insulated steel face panels—*air tight, reduce loss of heat from regenerators.*
9. Metal flashing—*no leakage between bus flues.*
10. Short division walls, triple-thick—*the only regenerator area subject to cross leakage.*
11. Forced air system—*positive control of decarbonizing of burners.*
12. Simple latch at each lean gas reversing valve—*change over entire battery from one gas to another within five minutes.*
13. Positive interlock at each gas reversing valve—*air and lean gas cannot be admitted at the same time.*
14. Self sealing oven doors and self sealing leveling doors with renewable sealing edges—*gas tight, easy maintenance.*
15. Hydraulic door machines—*smooth operation, low maintenance.*

WILPUTTE COKE OVEN DIVISION

ALLIED CHEMICAL & DYE CORPORATION

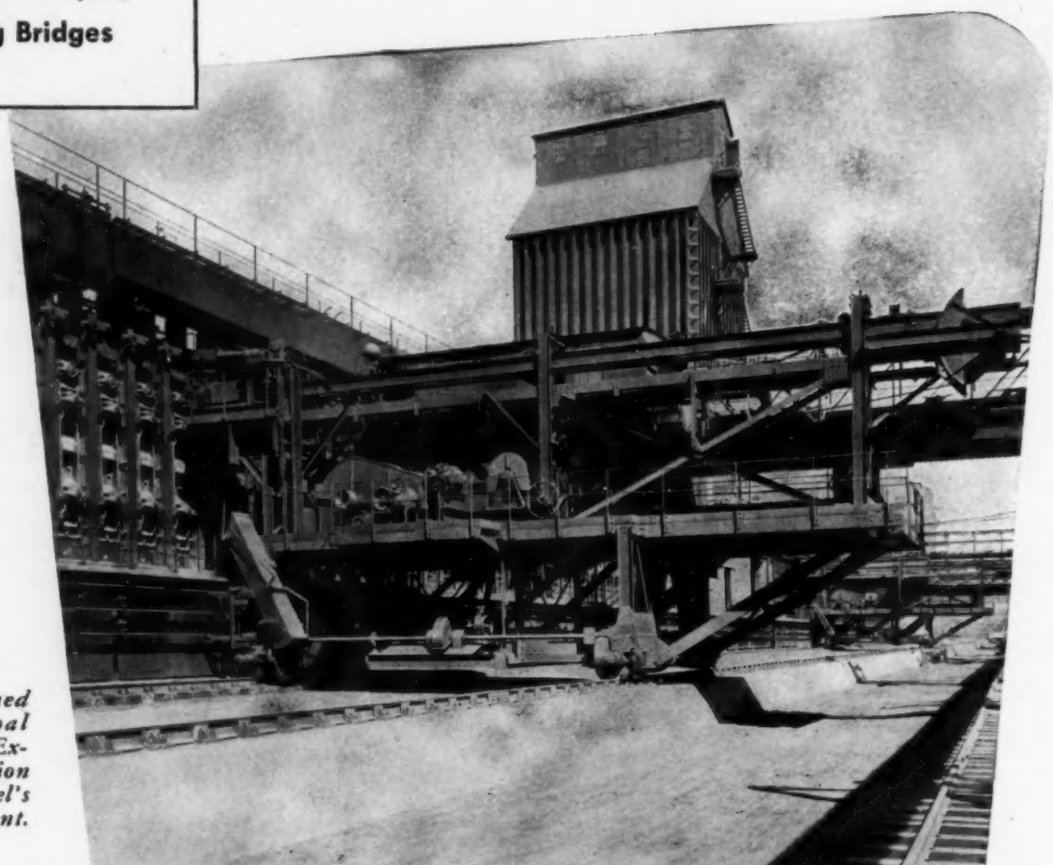
40 RECTOR STREET NEW YORK 6, N. Y.

Wellman will build it

- Coke Guides
- Coke Pushers
- Coke Quenching Cars
- Door Extractors
- Door Machines
- Coal Charging Larries
- Revolving Car Dumpers
- Coal Handling Bridges

Wellman Coke Pushers

for the Modern Coke Plant



Wellman Combined Coke Pusher, Coal Leveler and Door Extractor in operation at Bethlehem Steel's Lackawanna Plant.

● Many of the world's most modern byproduct coke oven plants are Wellman equipped. The Wellman Engineering Company's more than half-century experience in building heavy machinery guarantees sound design and expert construction. Wellman equipment provides peak economy, maximum safety and trouble-free performance under a wide variety of operating conditions. For conservative, reliable recommendations on your heavy equipment, phone or write:

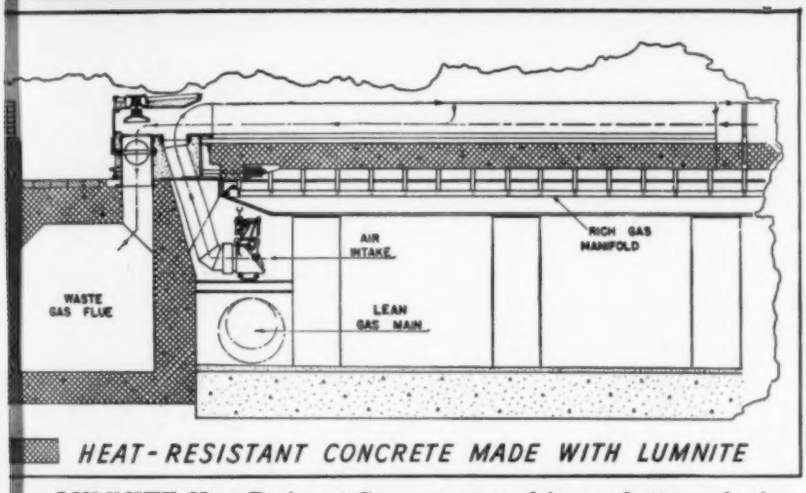
THE WELLMAN ENGINEERING COMPANY

7031 CENTRAL AVENUE • CLEVELAND 4, OHIO

For High-Temperature Service in Coke Plants:

LUMNITE CONCRETE

Base slab of Heat-Resistant Concrete made with LUMNITE Cement. Waste-gas flues at left also built with LUMNITE Concrete.



ove) LUMNITE Heat-Resistant Concrete as used in new battery of coke ns at Lorain Works, National Tube Company. **(Below)** Interior of waste- flue built with LUMNITE concrete, no lining needed.

Uses of LUMNITE in Coke Plants:

Heat-Resistant Concrete. Base slab supporting regenerators. Waste-heat tunnels and flues. Paving of battery tops and benches.

Refractory Concrete. Door linings. Riser-pipe linings. Wind-box and flue linings. Replacement linings in waste-heat tunnels and flues. Patching around jambs, inspection and charging holes. Precast shapes—inspection-hole blocks, charging-hole blocks, riser-pipe seat blocks, lintels.

Corrosion-Resistant Concrete. Stack linings and mortar for brick stacks. Quenching tower foundations, lining and mortar. Floors, foundations, and protective coatings to resist ammonium sulphate and sulphuric acid.

Rapid-Hardening Concrete. Replacing pusher-track foundations. Emergency replacement of pavements, foundations and other structural concrete.

Write for information on aggregates and mixes used in making these special LUMNITE concretes for coke-plant service.

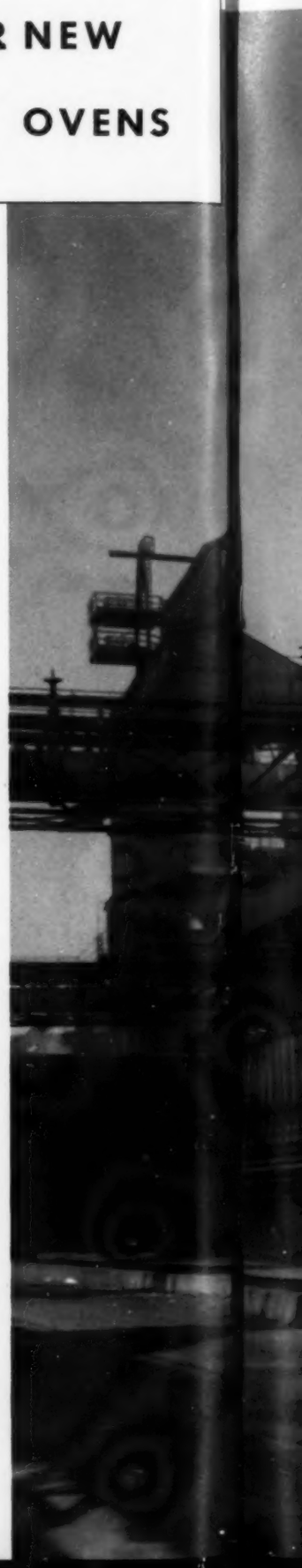
Lumnite Division

UNIVERSAL ATLAS CEMENT COMPANY

UNITED STATES STEEL CORPORATION SUBSIDIARY

135 EAST 42nd STREET • NEW YORK 17, N. Y.

CARNEGIE-ILLINOIS HAS RECENTLY PUT INTO OPERATION ANOTHER NEW BATTERY OF KOPPERS-BECKER OVENS



At the Clairton, Pennsylvania, Plant of the Carnegie-Illinois Steel Corporation, the Engineering and Construction Division of Koppers Company, Inc. recently put into operation the second of two large batteries of Koppers-Becker Underjet ovens provided with Koppers Waste-gas Recirculating System.

Each individual oven is 42 feet, 7½ inches long, 14 feet high and 18 inches in average width with a 3 inch taper. It will hold 22 net tons of coal, which is the largest capacity of any oven in the United States. Together the two batteries of 174 ovens are capable of carbonizing approximately 5,000 net tons of coal per day.

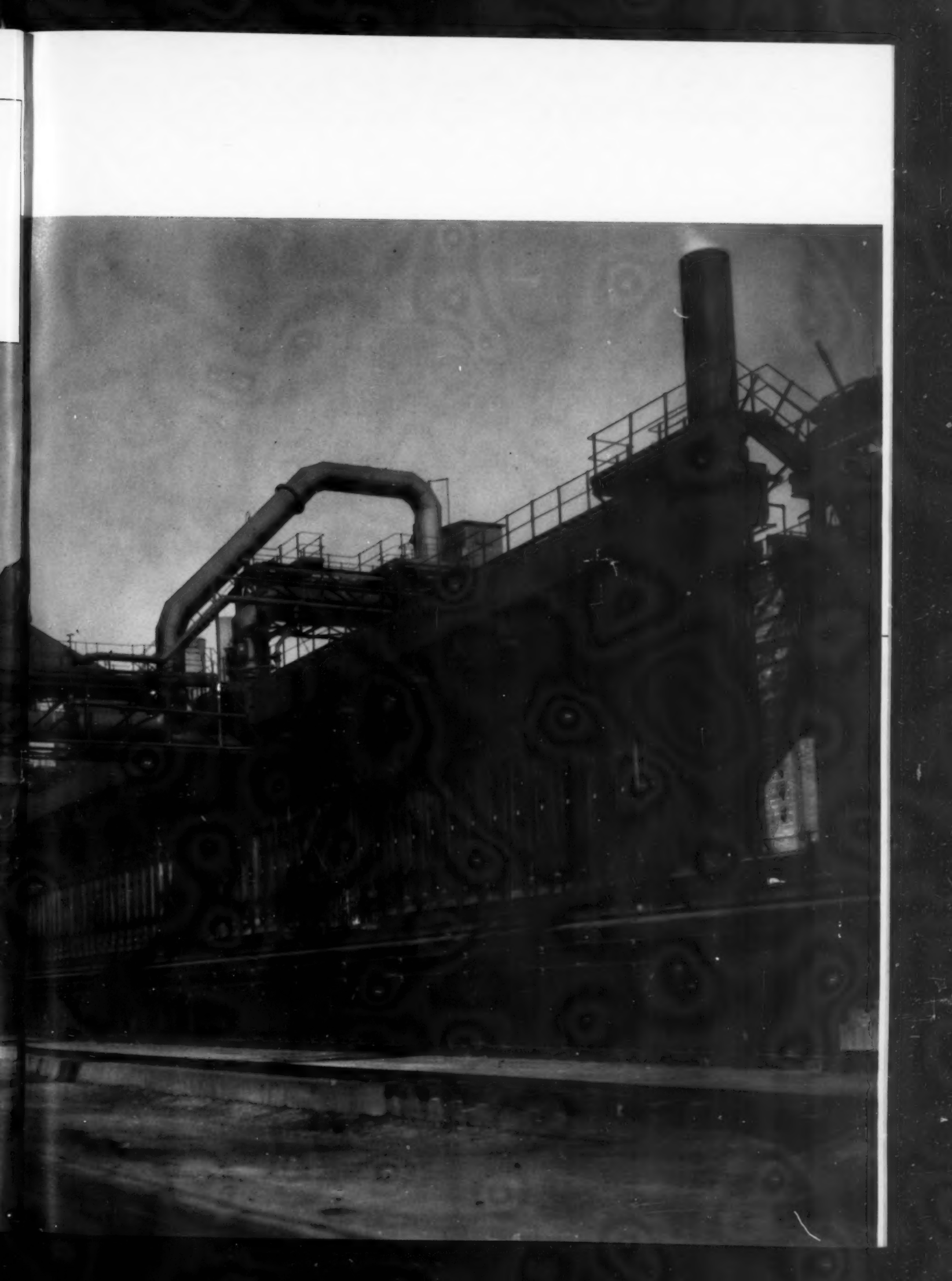
These batteries are provided with Koppers patented self-sealing doors, double gas-collecting mains and saddle-brick oven-wall construction.

Koppers is now replacing one battery of 61 ovens at Clairton and adding a new battery of 85 ovens. When these are completed, Clairton will operate 1567 ovens with a rated coal-carbonizing capacity in excess of 32,000 tons per day. It is the largest coke plant in the world.

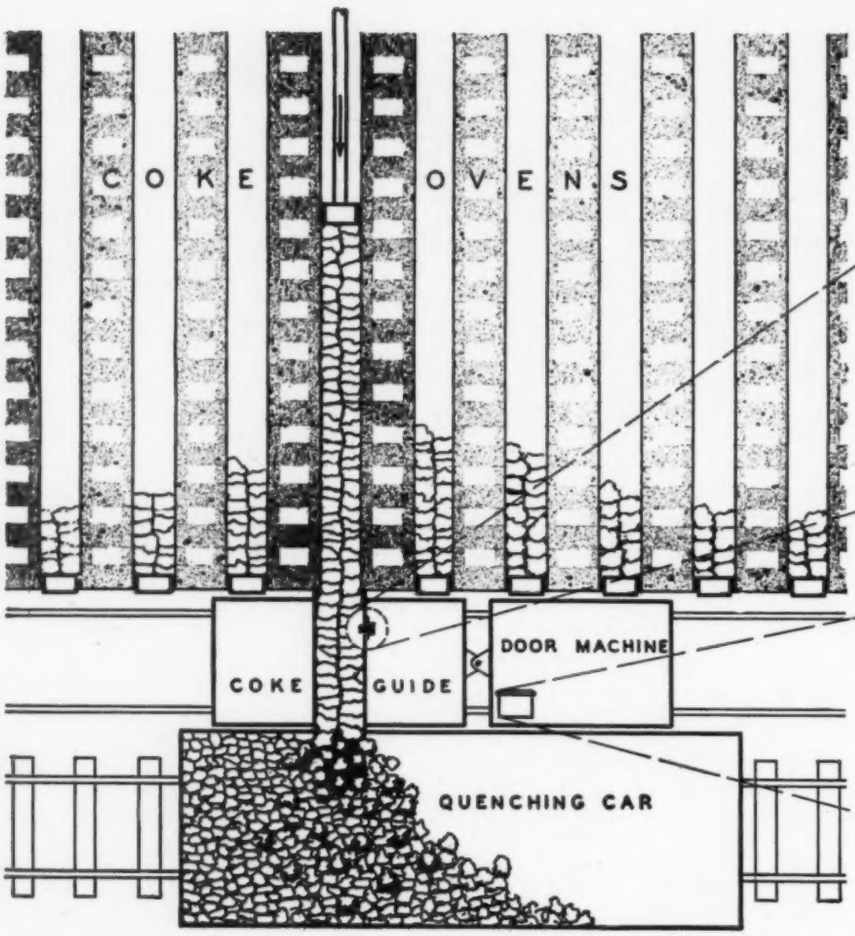
KOPPERS COMPANY, INC.

Pittsburgh 19, Pa.

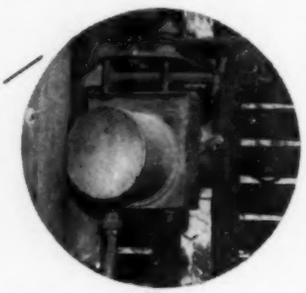
K
KOPPERS



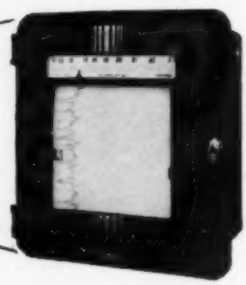
New Way To Get COKE TEMPERATURES . . . *AUTOMATICALLY!*



1. Diagram shows the set-up by which Citizens' Gas & Coke Company, Indianapolis, measures temperature across the charge of coke as it is pushed from the oven.



2. *Rayotube* on side of coke guide detects temperature of hot coke moving past to the quench car



3. *Speedomax* mounted in the cab of the oven door's operating machine continuously records temperature detected by Rayotube along the entire length of coke charge from front to back.

Coke plants can now measure coke temperatures *entirely automatically*, with a Speedomax Recording Pyrometer and Rayotube temperature detector. This equipment has proved highly successful in helping to maintain better control of oven operation — and better control of coke and by-product quality.

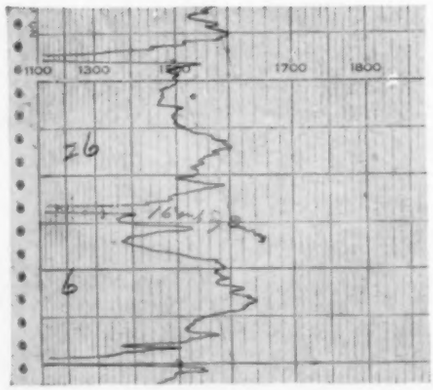
Measurements are instantaneous and complete. Because each temperature variation is recorded faithfully, the operator can tell exactly how uniformly the oven has been heated. Hot and cool spots show immediately on the chart.

By comparing records of successive loads from the same oven, operator can see the effect of changes in burner setting. This accurate information helps him bring each oven to specified temperature and uniformity.

Both Speedomax and Rayotube are entirely insensitive to vibration of the coke guide — yet they are highly sensitive to temperature. They are built to work together as a temperature-measuring team under really severe operating conditions.

An L&N engineer will be glad to discuss your problem with you, or will send Catalog N-33B. Leeds & Northrup Co., 4942 Stenton Ave., Philadelphia 44, Penna.

4. *Highly detailed record* drawn by Speedomax is shown below about half size. The variations shown are considered too great for ideal conditions.

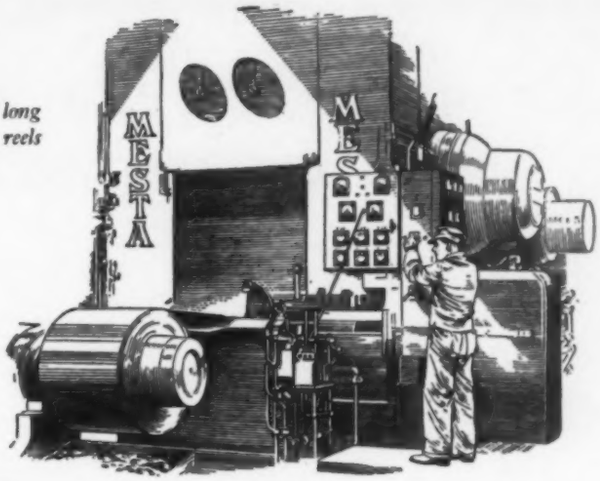


MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

LEEDS & NORTHRUP CO.

Jrl. Ad N-33B-705(1)

Torrington Tapered Roller Bearings provide long service life and efficient performance in Mesta reels because of their high radial and thrust capacity.



Finishing Greater Tonnages on Torrington Tapered Roller Bearings

... another advantage is the long service life assured by the high radial and thrust capacity of these Torrington Bearings.

RECORD TONNAGES are coiled on the Mesta cold mill reel at the high tension required for quality control. Advantages are provided by Torrington Bearings on the 11-foot drive shaft. The high radial and thrust capacity of these bearings provides rigid reel support, accurate alignment, axial stabilization and long service life under critical load conditions. High-speed production proceeds steadily with minimum down-time for maintenance.

This is only one instance of the outstanding performance of Torrington Bearings in the steel industry. You get these and other benefits when you use them on roll necks, screw downs, shears, edgers, table rolls, drives, pinion stands and other heavy-duty applications.

To secure improved performance from your equipment, you can count on the specialized knowledge and years of experience of Torrington's engineers—in designing, building and applying all types of anti-friction bearings. Call or write the nearest Torrington office.

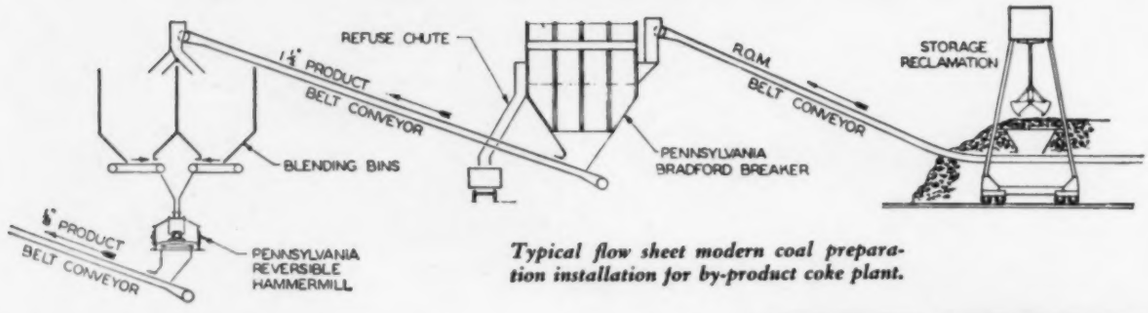
THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.
District Offices and Distributors in Principal Cities

TORRINGTON BEARINGS

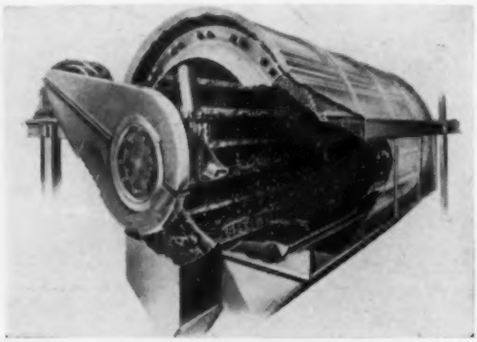
SPHERICAL ROLLER
TAPERED ROLLER
STRAIGHT ROLLER
NEEDLE
BALL
NEEDLE ROLLERS

"PENNSYLVANIA" STEELBUILT

BRADFORD BREAKERS AND HAMMERMILLS for the MODERN COKE PLANT

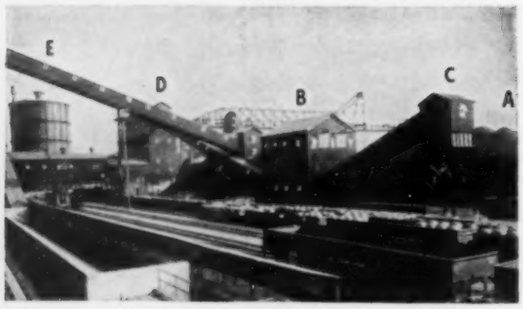


Typical flow sheet modern coal preparation installation for by-product coke plant.

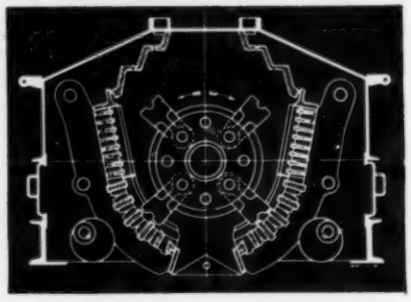


"Pennsylvania" Bradford Breaker phantom view.

"Pennsylvania" Reversible Hammermills, usually two or more.



Typical by-product coal handling installation. (A) Coal pile (B) Bradford Breaker building (C) Bradford refuse disposal (D) Blending and Hammermill building (E) Conveyor to coke ovens.



Sectional view, typical "Pennsylvania" Reversible Hammermill.

Preparation of coal for coking is an important step in the manufacturing of steel. The Bradford Breaker conditions ROM coal . . . reduces to 1½" size and removes wood, iron, rock, slate and other debris from the coal. High, low, and medium volatile coals are treated separately prior to mixing and pulverizing to a nominal ⅛" size in REVERSIBLE Hammermills.

Blending and mixing of the coal is extremely important to insure proper coking qualities, and the reduction to ⅛" in Reversible Hammermills permits proper blending, further reduces and distributes high ash, slate or other inclusions, assuring a coke of maximum strength and density which is highly desirable for good blast furnace practice.

"Pennsylvania" Bradford Breakers, followed by "Pennsylvania" Hammermills, were installed early in the 1900's with Heinrich Kopper's first By-Product coke plant. These early units and improved models have been standard equipment throughout the Industry since that time. Well over 90% of the Coke Plants in this country are equipped with "Pennsylvanias."

STEELBUILT construction, trouble-free operation over long periods, accessibility and high efficiency have assured "Pennsylvania" equipment continued patronage by modern Coke Plant operators.

Engineering services are available. Details and bulletins on request.

PENNSYLVANIA CRUSHER COMPANY

Liberty Trust Bldg. Philadelphia 7, Pa.

New York • Pittsburgh • Chicago • Los Angeles • Birmingham
Associated with Fraser & Chalmers Engineering Works, London

Clevelands

IN THE MODERN COKE PLANT

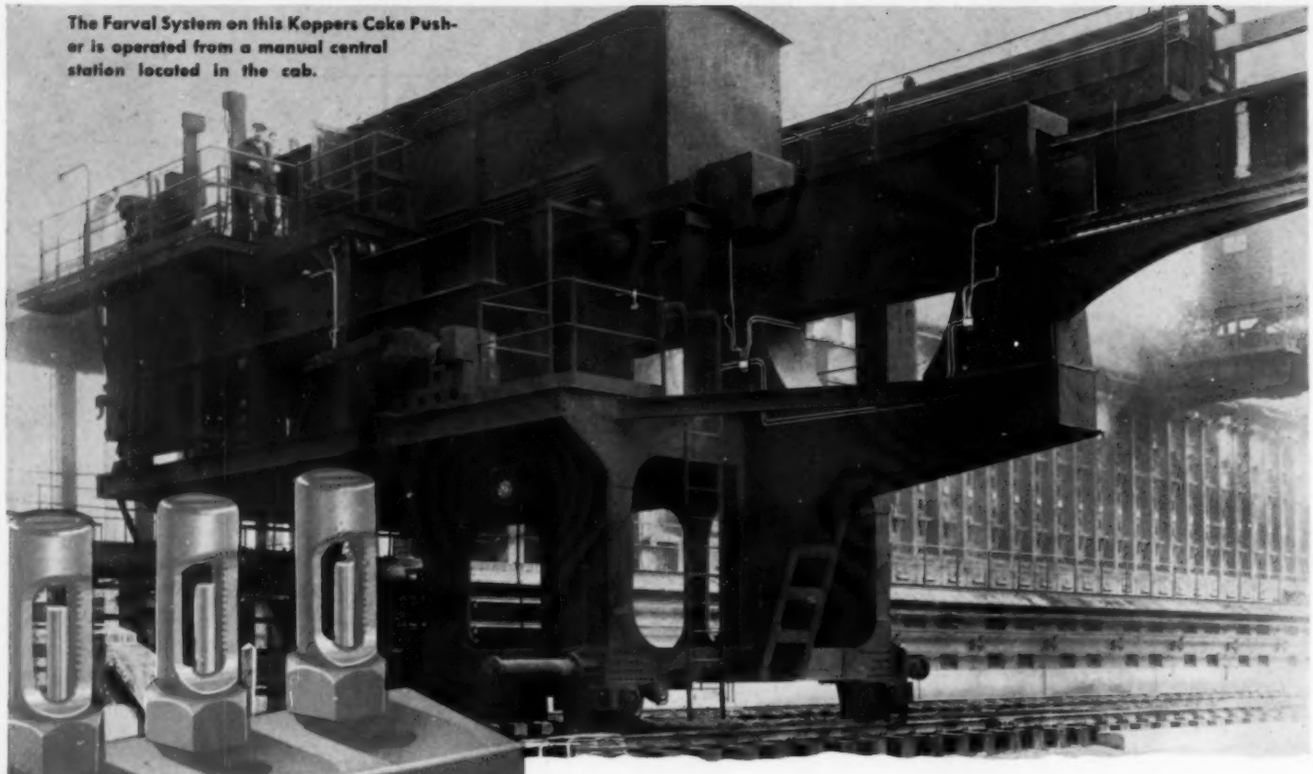
THROUGHOUT the modern coke plant you see Cleveland Worm Gear Speed Reducers. They drive reversing machines, coke guides, conveyors, gate opening drives on larry cars, door machine turning drives and elevator drives, and other machines where the dependability of a compact, right-angle worm gear drive is essential to continuous production.

Each new development in the production of steel has brought an increasing demand for Cleveland Worm Gear Drives throughout the mill. Wherever they serve, you can depend on Clevelands for satisfactory, continuous performance. The Cleveland Worm & Gear Company, 3278 East 80th St., Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

Above: *Battery of Koppers Coke Ovens where scores of Cleveland units are installed.*

At left: *Cleveland unit driving Wilputte reversing machine.*



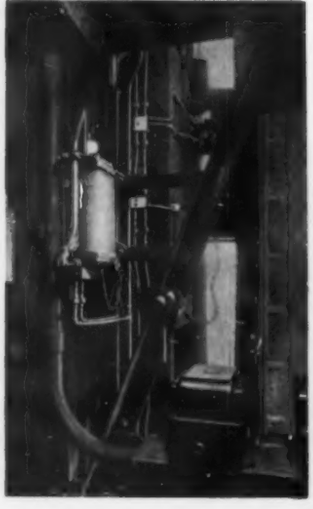
The Farval System on this Koppers Coke Pusher is operated from a manual central station located in the cab.

FARVAL in the modern coke plant

MORE than 200 Farval Systems of Centralized Lubrication have been installed on coke oven equipment since the advent of the modern coke plant in the steel industry. Today Farval protects the bearings of such vital equipment as coal charging cars, coke guides, pushers, reversing machines, door machines, larry cars, door extractors, conveyors, and fuel gas reversing cocks.

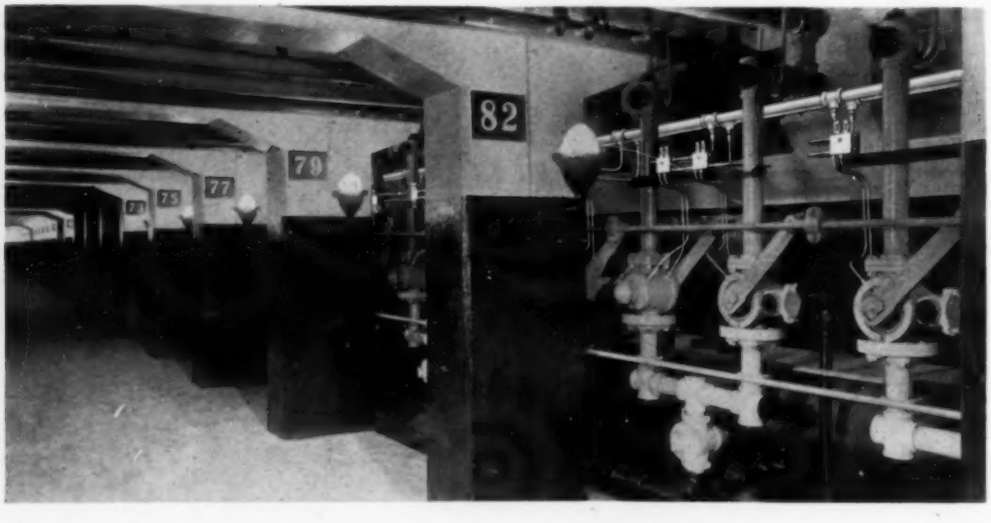
Where lubrication of bearings is important to efficient operation of equipment, there you find Farval. In fact, there are more Farval Systems installed on Steel Mill equipment than all other makes combined. The Farval Corporation, 3278 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.



Close-up of Farval manual pumping station and lubricating valves on Door Extractor.

Below — Farval systems protect the bearings of the fuel gas cocks on this battery of Wilputte coke ovens.



PHOTOELASTIC ANALYSIS OF

Stresses in Crane Ladle Hooks

. . . . this report covers one of two research programs on ladle hooks being sponsored by the Association of Iron and Steel Engineers . . . . this report describes how to accurately compute the bending and direct stresses normally considered in hook design . . . . the other program under way will evaluate the effect of forces not normally considered, such as temperature, lack of uniform bearing, etc., which are fully as important if not more so than the stresses covered in this report . . . .

By F. K. CHANG, K. E. KNUDSEN and BRUCE G. JOHNSTON

Fritz Engineering Laboratory

Lehigh University

Bethlehem, Pennsylvania

▲ HEREIN are reported photoelastic tests of five ladle hooks which have shapes similar to typical designs as furnished by manufacturers. These tests cover stresses due to load only, no consideration being given to temperature effects. It is recognized that the stresses due to elastic behavior of a hook, as obtained from a photoelastic test, do not necessarily have a direct relation to the ultimate strength of the steel prototype, particularly if the steel behaves in a normal ductile manner when the yield point is exceeded. Nevertheless, maximum stress is commonly a criterion of design, particularly relevant if repeated loads leading to fatigue failure are a possibility.

Figures 1, 2, 3, 4, and 5, inclusive, show the dimensions of the five hook models, which will hereinafter be referred to as Hooks A, B, C, D, and E, respectively. All of the hook models were made of clear bakelite, as furnished for photoelastic purposes, and were carefully polished and machined to the outline dimensions. The models were loaded by means of the steel jig shown by photograph in Figure 6, with Hook B in place. At the point of application of the load the radius of the steel bearing element was 0.15 inches.

The Association of Iron and Steel Engineers defrayed the cost of making the test jig, machining the photoelastic specimens, and furnished drawings of the prototypes. The tests were made at the Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pennsylvania.

* Numbers refer to bibliography at end of article.

STRESSES IN CURVED MEMBERS

An approximate theory of stress analysis of curved bars of constant curvature and constant cross-section, under pure bending was developed in 1858 by E. Winkler(1)*. The ladle hooks are not generally uniform in cross-section, nor in curvature, and are loaded with a combination of bending and direct stress instead of pure bending. Nevertheless, these photoelastic tests furnished evidence of the applicability of Winkler's theory to the stress determination in the curved barb region of ladle hooks. This theory is relatively simple and is derived in detail in books on strength of materials, by Timoshenko(2) and others.

In a straight beam, of constant cross-section, under tensile force P, the average direct stress σ_a is:

$$\sigma_a = \frac{P}{A} \qquad (1)$$

where A is the area of the cross-section. If the bar is under "pure bending," the direct stress is given by

$$\sigma_b = \frac{My}{I} \qquad (2)$$

where

M = applied bending moment about centroidal axis.
y = distance from centroidal axis.
I = static moment of inertia of the cross-section area, about the centroidal axis.

The stress is maximum in magnitude when y = c, where c is the distance from the centroid to the extreme fiber at the surface of the beam at the inside of the hook.

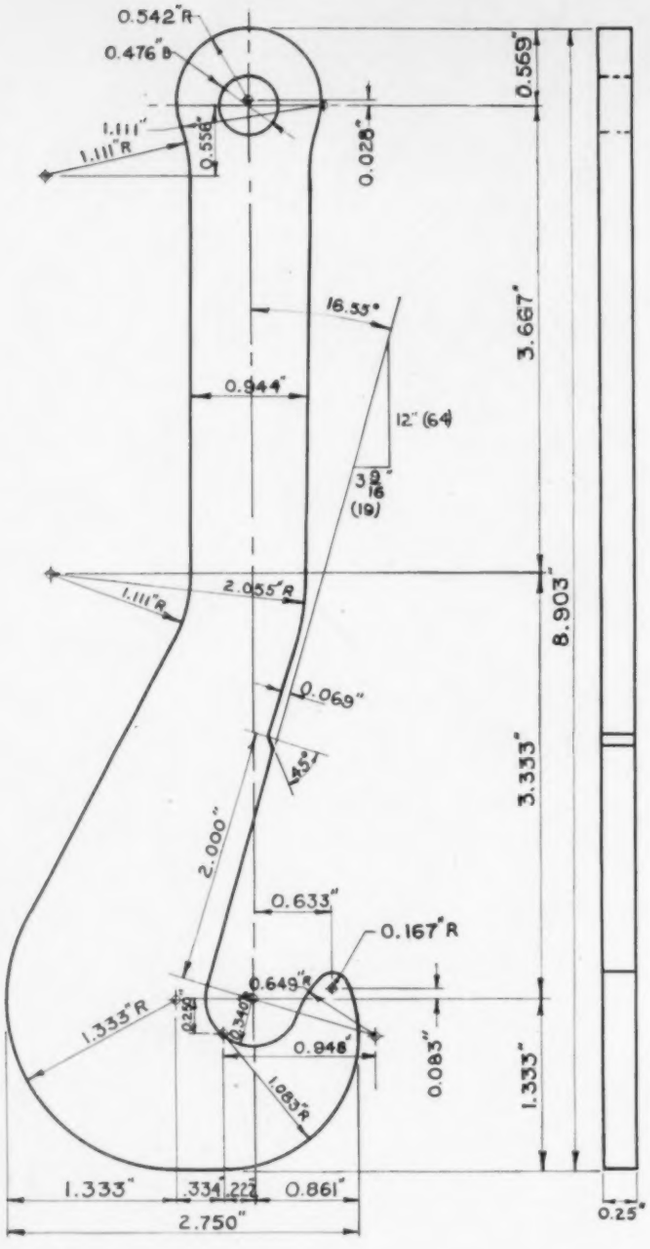


Figure 1 — Ladle crane hook "A." Model scale is 1:18.

Under combined bending and direct stress, the foregoing expressions are added and the stress is:

$$\sigma = \frac{P}{A} + \frac{My}{I} \qquad (3)$$

Direct stress in tension is designated by a plus sign, in compression by a minus sign.

Equation (3) may be applied to curved bars, if the curvature is slight, but stresses so determined will be very much in error in the case of bars curved as sharply as the ladle hooks studied in this investigation.

The application of Winkler's theory of curved beams, considering only pure bending, leads to the following formula for direct stress:

$$\sigma_b = \frac{KMy}{I} \qquad (4)$$

where K is a modifying factor applied to the straight beam equation for direct stress due to bending.

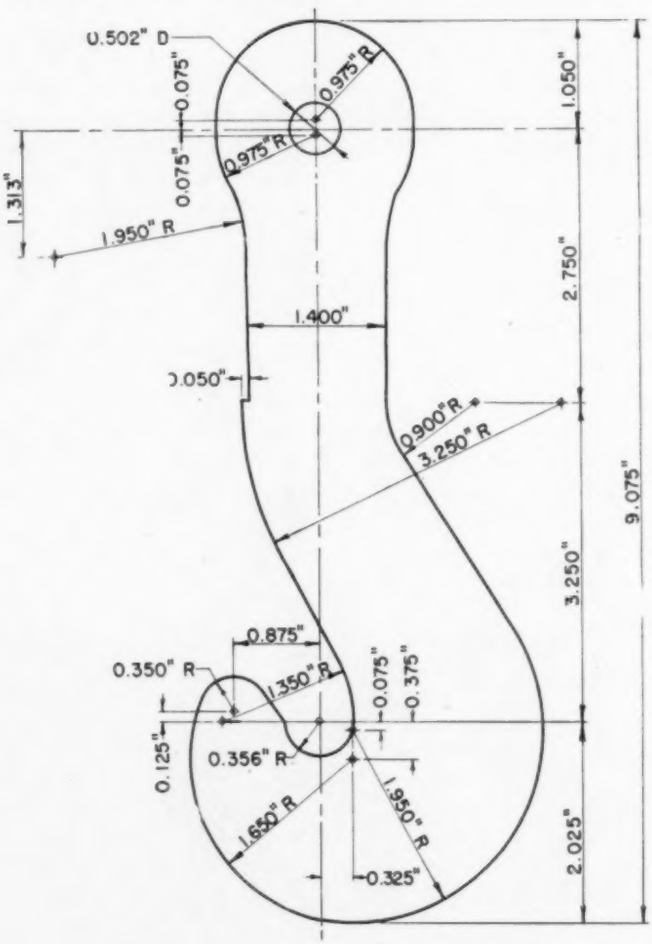
Using the notation shown in Figure 7, and assuming M to be positive when the moment tends to straighten the curved bar, for the special case of the rectangular section:

$$K = \frac{\frac{2c}{y} - \alpha\left(\frac{R}{y} - 1\right)}{3\left(\frac{R\alpha}{c} - 2\right)\left(\frac{R}{c} - \frac{y}{c}\right)} \qquad (5)$$

where $\alpha = \log_e \left[\frac{\frac{R}{c} + 1}{\frac{R}{c} - 1}\right]$

The maximum tension stress is at the inside of the curved bar, where y = e, in which case

Figure 2 — Ladle crane hook "B." Model scale is 1:20.



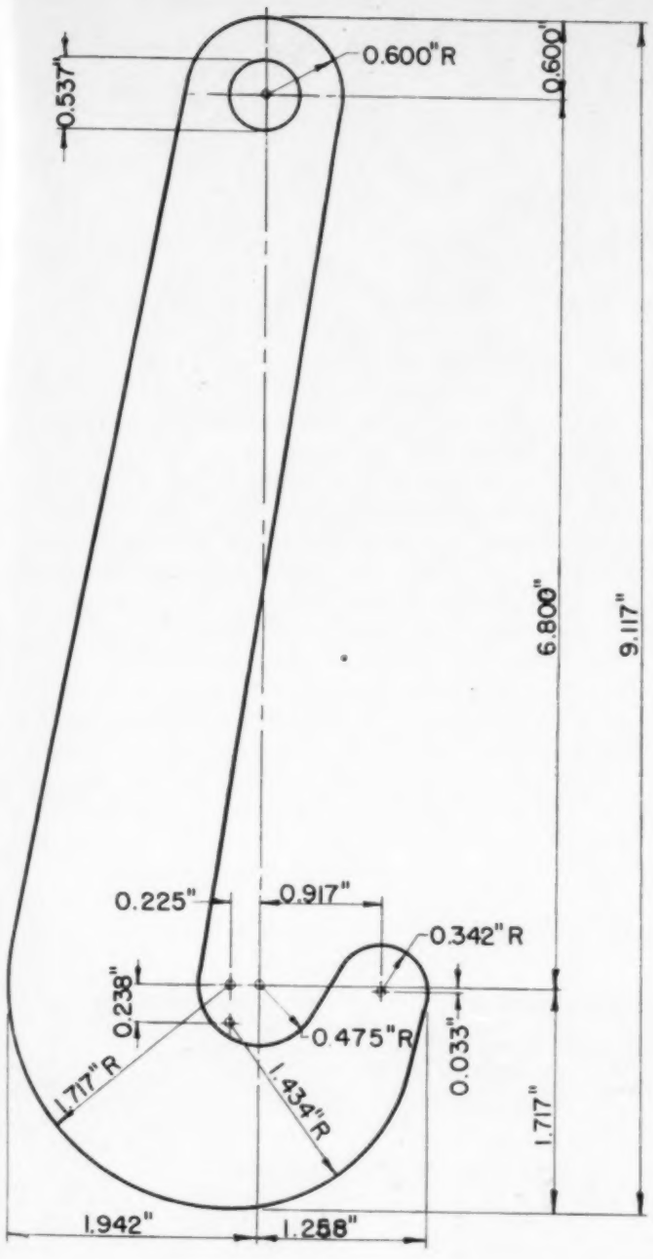


Figure 3 — Ladle crane hook "C." Model scale is 1:15.

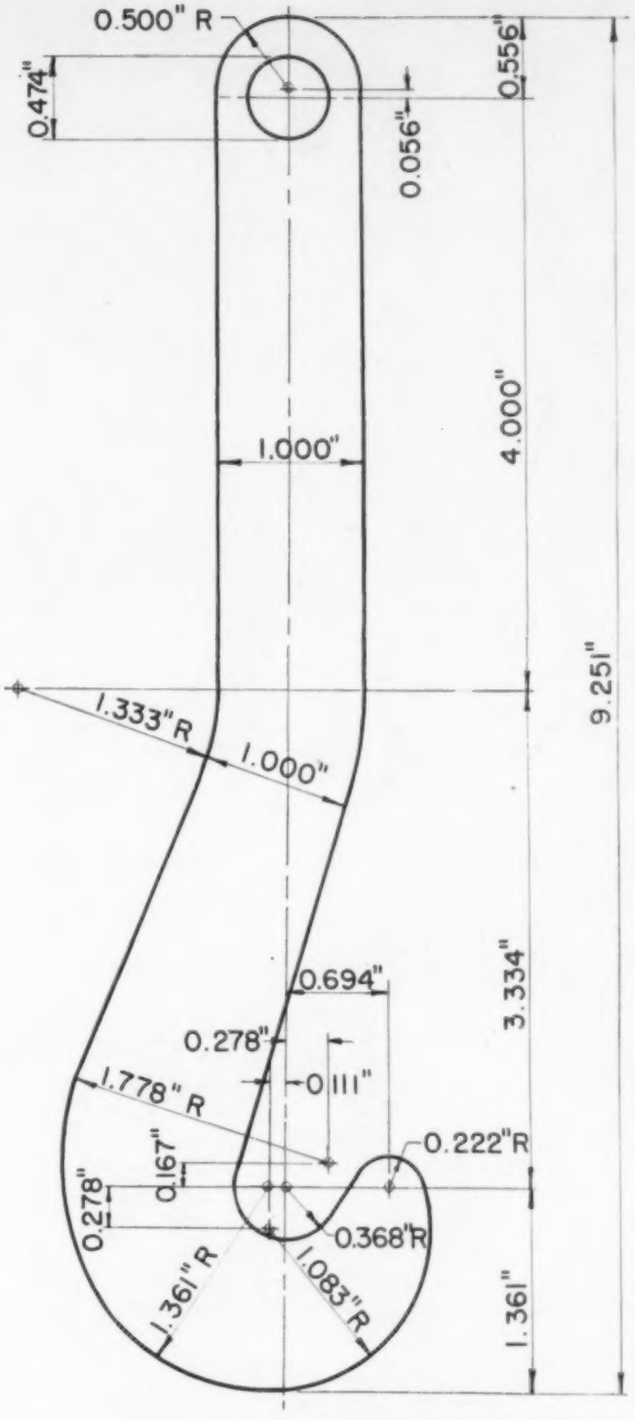


Figure 4 — Ladle crane hook "D." Model scale is 1:18.

$$K_t = \frac{2 - \alpha\left(\frac{R}{c} - 1\right)}{3\left(\frac{R}{c} - 2\right)\left(\frac{R}{c} - 1\right)} \qquad (6)$$

Values of K for cross-sections other than rectangular have also been evaluated(3). The solution of Equation (6) for the rectangular section is tabulated in the range of these tests in table I, right:

TABLE I

$\frac{R}{c}$	K_t	$\frac{R}{c}$	K_t
1.2	2.89	1.8	1.63
1.3	2.39	1.9	1.57
1.4	2.10	2.0	1.52
1.5	1.92	2.1	1.48
1.6	1.79	2.2	1.45
1.7	1.70	2.3	1.42

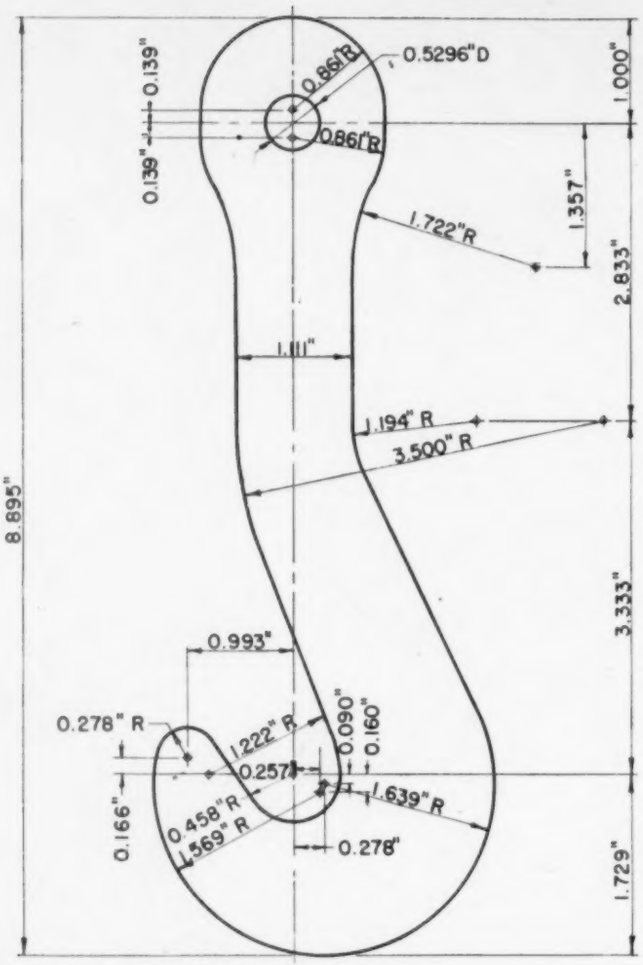


Figure 5 — Ladle crane hook "E." Model scale is 1:18

When a curved bar is subjected to combined tension and positive bending moment, as in the case of a hook, it has sometimes been assumed that the maximum tensile direct stress could be evaluated as the sum of the average tension stress (Equation 1) and the maximum tension due to curved beam bending (Equations 4 and 6), i. e.

$$\sigma_{max} = \frac{P}{A} + K_t \frac{Mc}{I} \qquad (7)$$

In an investigation of curved beams by the photoelastic procedure, a more recent investigation(4) demonstrated that when M = O in Equation 7, the stress contributed by the direct tension, P, could not be assumed to be uniform in a curved beam. It was indicated that the maximum tension due to P was much greater than the average tensile stress, σ_a, and that a better approximation than Equation 7 would be obtained by multiplying σ_a as well as σ_b by K_t, giving

$$\sigma_{max} = K_t\left(\frac{P}{A} + \frac{Mc}{I}\right) \qquad (8)$$

In Table II, "Test Results," comparison is made between experimental values of σmax and those given by Equations 3, 7, and 8.

TEST RESULTS

The representative photoelastic(5) fringe pattern shown in Figures 8 and 9 for Hooks A, C, and D, were obtained using monochromatic light filtered from a mercury vapor lamp, and circularly polarized. The fringe order, noted by numbers in Figure 9, multiplied by the fringe value, gives the difference in principal stresses, P — Q, where

P = maximum principal stress (algebraic maximum)

Q = minimum principal stress (algebraic minimum)

Along an unloaded boundary, one of the principal stresses is always zero, hence the "boundary stresses" are directly proportional to the "fringe order."

Boundary stresses were determined in all of the tests and are plotted in Figures 10 and 11. In Table II are summarized the maximum boundary stresses in the region of the barbs for each of the five hooks.

A comparison of Rows ① and ②, and a study of Figure 11 shows that the tensile boundary stress was generally maximum at a point somewhat below Section AA of Figure 7. Rows ③ and ④ show the inadequacy of the "straight line" Equation 3, which gives too low an estimate of the maximum stress on Section AA by ratios varying from 1.57 to 2.05.

Figure 6 — Hook "B" is here shown in the testing rig.

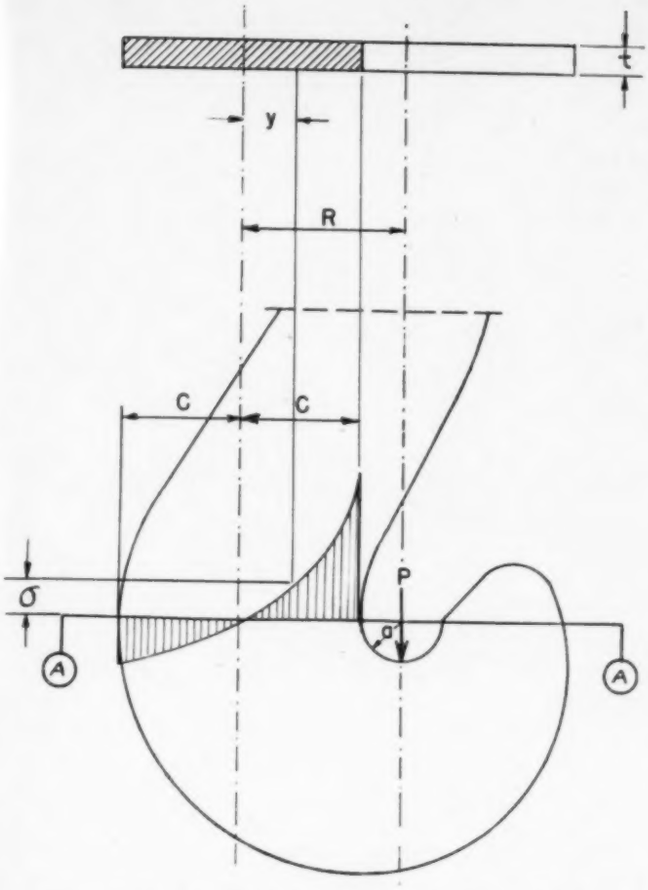
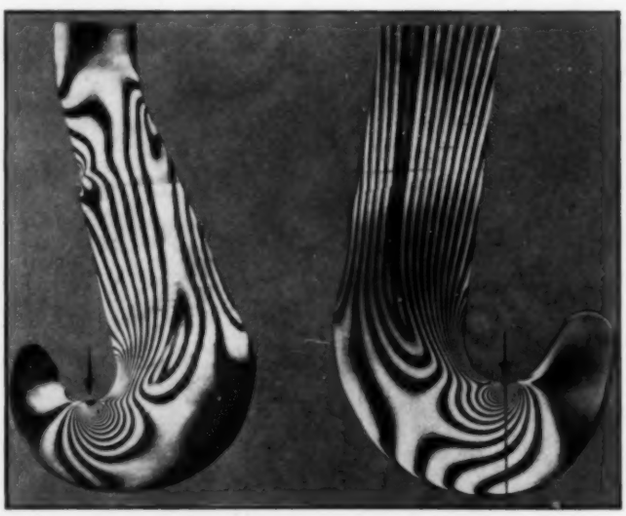


Figure 7 — This sketch is drawn to illustrate the nomenclature in the stress formulae.

Equation 7, wherein the curved beam correction factor K_t is applied only to maximum stress due to bending, is in reasonably good agreement with the maximum stress on Section AA, by photoelastic test. (See Rows ①, ④, and ⑦.) The maximum discrepancy is six per cent. It is to be noted that Section AA is at

Figure 8 — On left is shown fringe photograph of hook "A," and on right is shown a fringe photograph for hook "C."



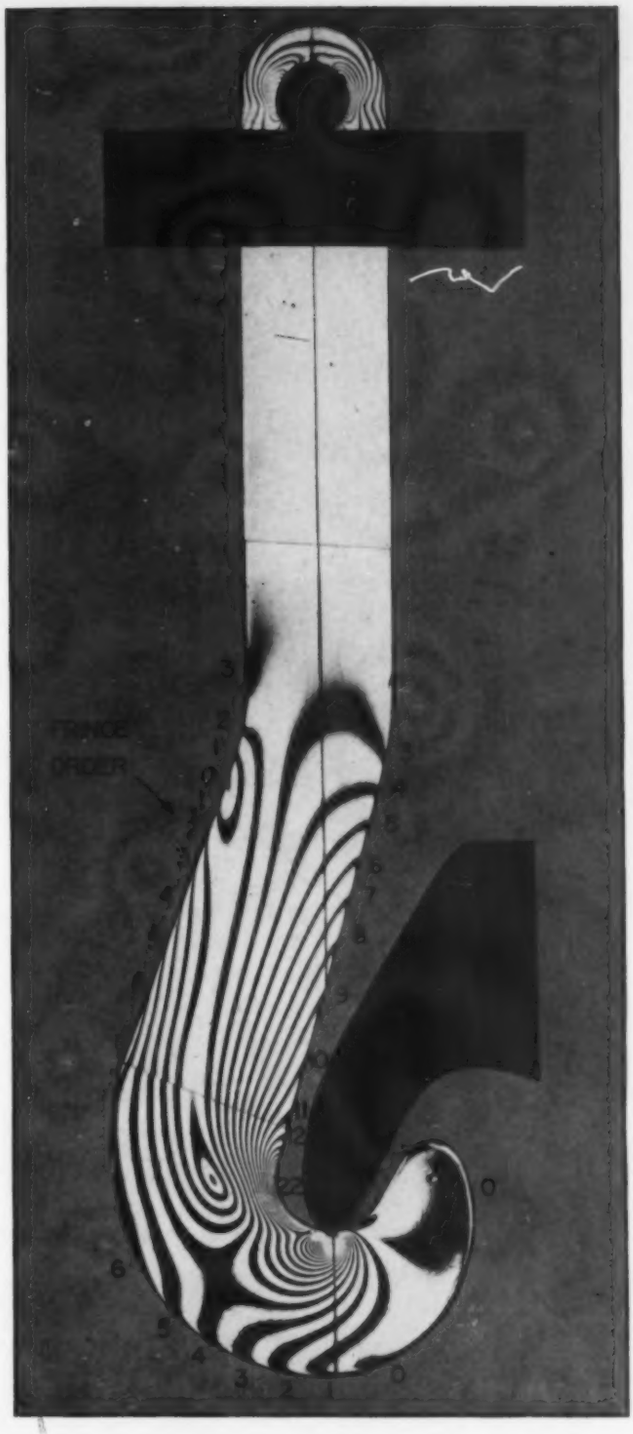


Figure 9 — Fringe photograph of hook "D." Note stress concentration at load point. High stresses are indicated by close spacing of the fringe.

or near the juncture of the curved and straight portions of the hook barbs.

Equation 8 overestimates in all five hooks the maximum stress photoelastically determined on Section AA, although the maximum difference is about twelve per cent.

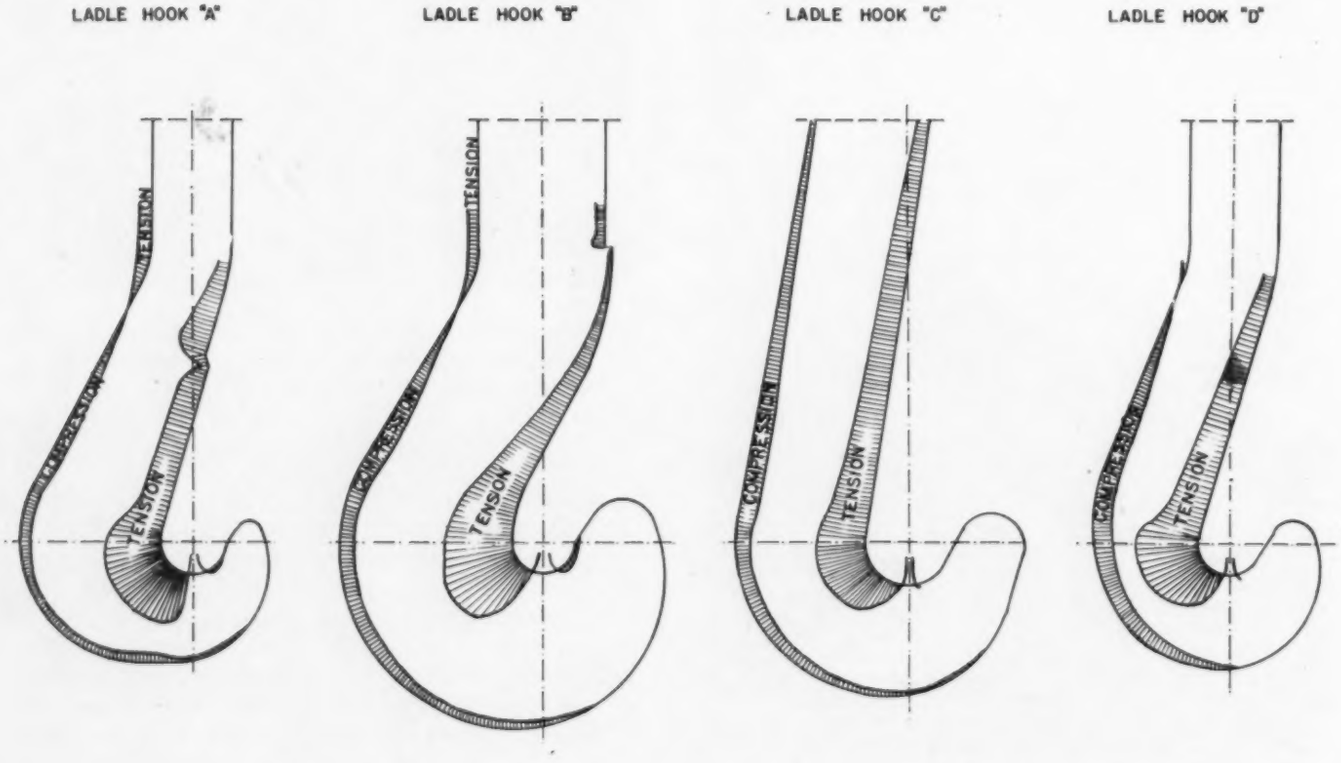
Although calculated only for Section AA, it is noted by Row ⑱, Table II, that Equation 8 gives a better indication of the maximum boundary stress which

TABLE II

	Hook	A	B	C	D	E
①	Maximum stress, by test, normal to Section AA (Figure 7)	6300*	7660*	5340	8550*	7300*
②	Maximum boundary stress by test between Section AA and load point	7100*	8930*	6360	8550*	8100*
③	Maximum stress computed by Equation 3	3250	3730	3390	5330	4470
④	Maximum stress computed by Equation 7	5960	7250	5600	8540	6950
⑤	Maximum stress computed by Equation 8	6590	8100	6050	9180	7900
⑥	Ratio Row ① / Row ③	1.94	2.05	1.57	1.60	1.63
⑦	Ratio Row ① / Row ④	1.06	1.06	0.95	1.00	1.05
⑧	Ratio Row ① / Row ⑤	0.96	0.95	0.88	0.93	0.92
⑨	Ratio Row ② / Row ④	1.19	1.23	1.13	1.00	1.16
⑩	Ratio Row ② / Row ⑤	1.08	1.10	1.05	0.93	1.02

*Adjusted to correspond to average stress of 1000 psi in straight shank.

Figure 10 — Boundary stresses for ladle hooks A, B, C, and D.



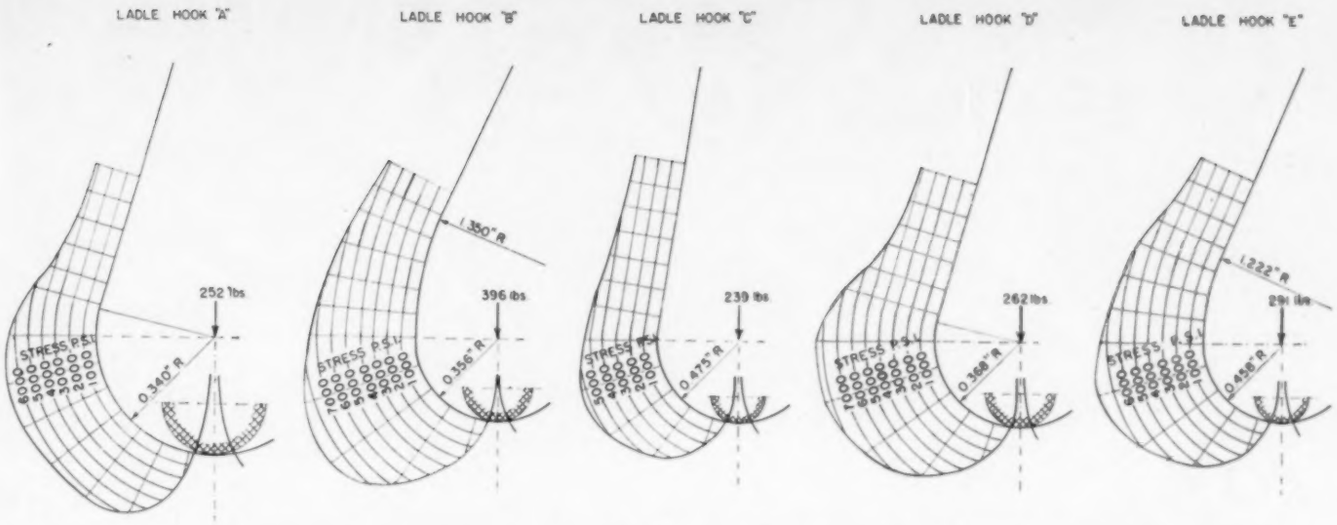


Figure 11 — Tensile stress along inside edge of ladle hooks in region of maximum. Loads and stresses for hooks A, B, D, and E have been adjusted to correspond to an average tensile stress of 1000 psi in the shaft where the cross section is uniform.

usually occurs somewhat below Section AA, than does Equation 7, which underestimates it in all cases except one, as shown in Row ⑨.

In the test of Hook B stresses were determined in the interior of the hook as well as at the boundary. The directions of the principal stresses are shown in Figure 12 determined from the isoclinics(5). Values of P + Q were determined throughout the model by the numerical difference equation procedure(5). Since the fringe photograph gives P — Q throughout the model, P and Q may be determined separately at any point. Figure 13 and 14 give contour maps of the magnitude of P and Q, respectively, throughout Hook B.

Figure 15 shows the vertical direct component of stress, σ, across Section AA, both by photoelastic test and by the Winkler curved beam theory, as given by Equation 7, substituting a variable factor K (Equation 5) in place of K_t (Equation 6), the latter being applicable only at the boundary.

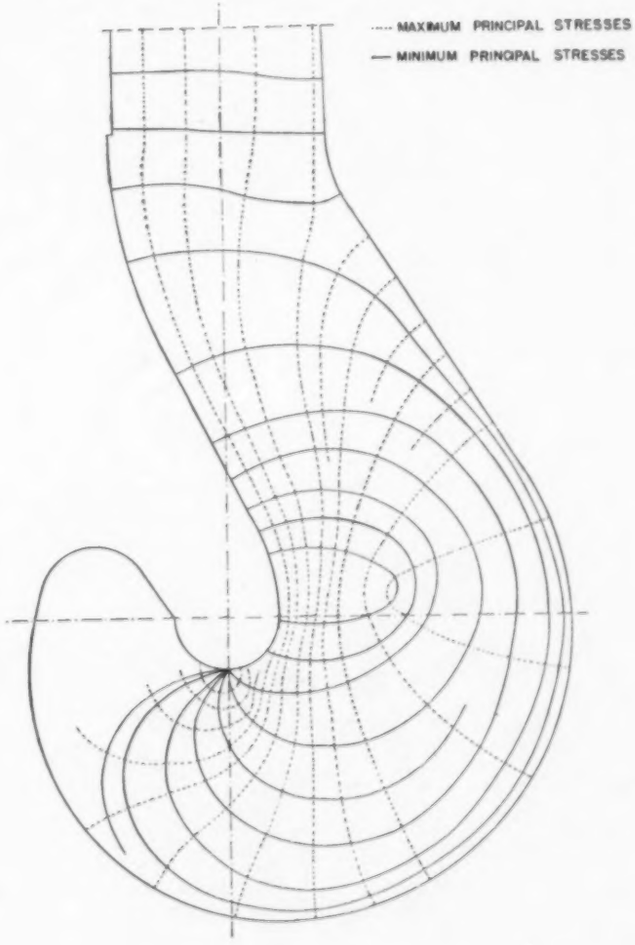
SUMMARY AND CONCLUSIONS

Photoelastic tests of bakelite models of hooks similar to five different actual designs showed that the Winkler theory for curved beams, as modified in Equation 8, with coefficients tabulated in Table I, gives a reasonably good approximation of the maximum tension stress on the inside curved portion of a ladle hook. In this procedure, the maximum normal stress is calculated only on Section AA of Figure 7.

In the straight shank of Hooks A, B, D, and E, the stress over most of the length is uniformly low compared to the maximum stress in the curved section. If the only design loads are the type applied in the photoelastic tests (no bending in shank), it is obvious that considerable reduction in weight could be safely effected by reducing the area in the straight section of the shank in these four designs.

In the curved hook section, it appears desirable to maintain the area nearly constant, from Section AA of

Figure 12 — Direction of principal stresses in ladle hook "B." Dotted lines show maximum and solid lines show minimum principal stresses.



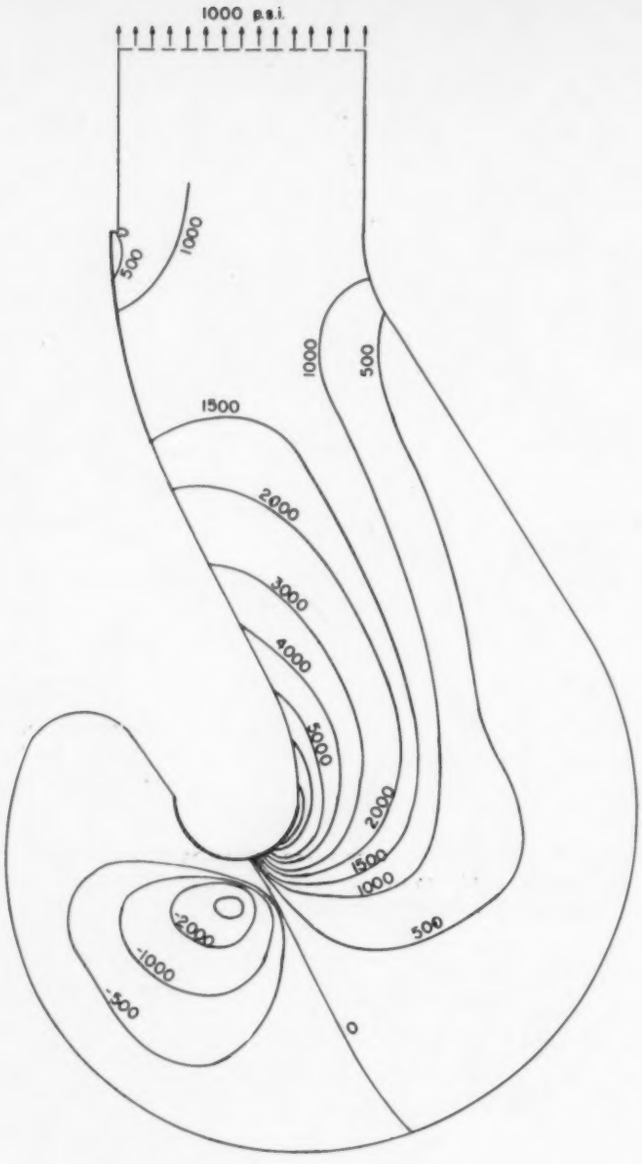


Figure 13 — Magnitude of maximum stresses in ladle hook "B."

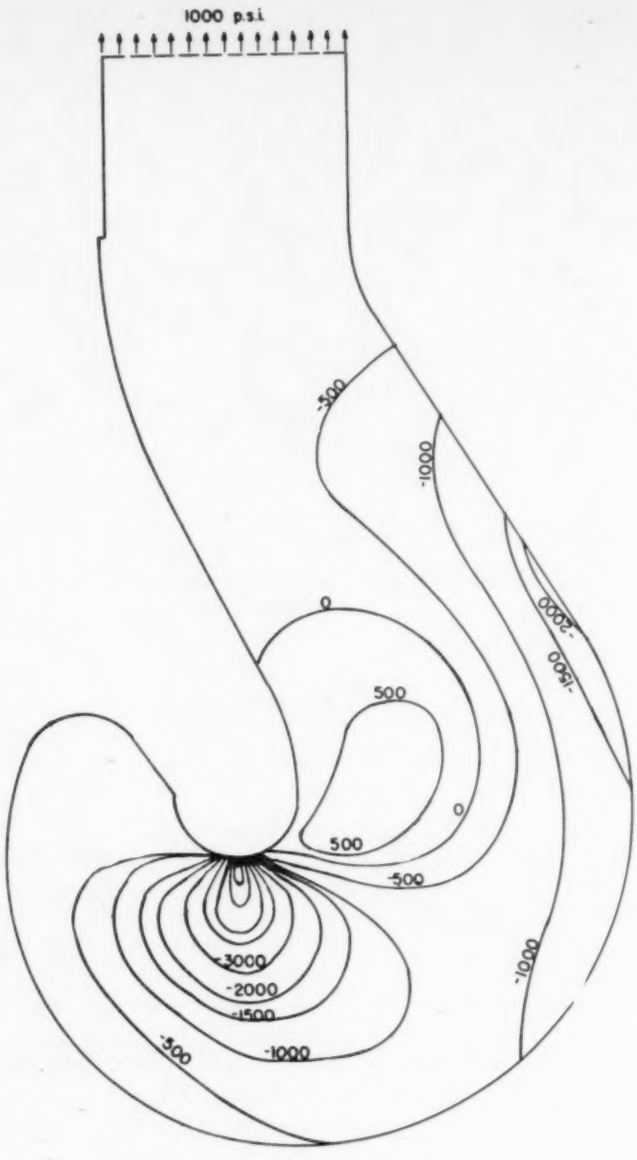


Figure 14 — Magnitude of minimum stresses in ladle hook "B."

Figure 7, downward through 90 degrees to the vertical section in the plane of the load.

A discussion of stresses near the pinhole in the top will not be included. In order to keep the models within a reasonable size, it was necessary to make the pin section undesirably small for photoelastic studies in this region.

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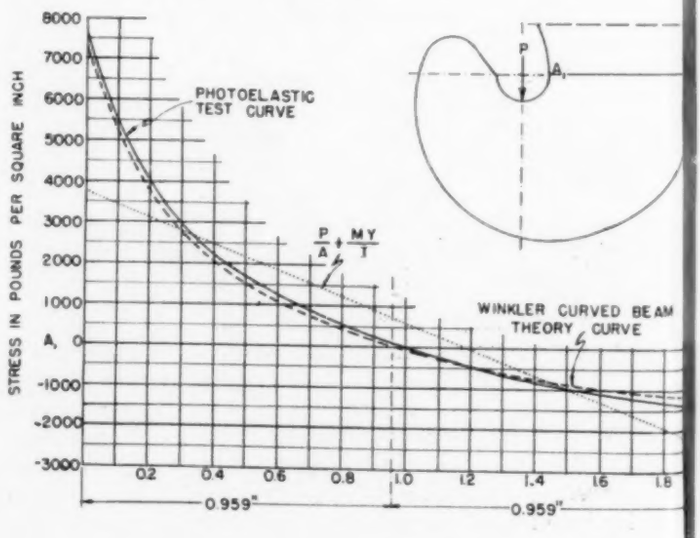
Figure 15 — Vertical normal stress distribution across section A-A of ladle hook "B."



METHODS FOR BRACING STATOR END WINDINGS

. . . . this description of several methods for tying end windings will be of particular interest to the steel mill maintenance man . . . .

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▲ ACROSS-the-line starting, sudden excessive loading and direct short circuits impose severe shock on the windings of electric motors and generators. To withstand these forces and to prevent insulation breakage and coil distortion, the end windings must be securely braced.

The scheme of tying or bracing is dependent upon the physical shape of the coil or winding, and upon the design of the surge ring or rings and the supporting brackets. The service duty of the machine determines the design and number of surge rings, and they in turn determine the number of ties per coil. We shall describe some of the schemes which are commonly found.

Figure 1 shows the schemes used for a half-turn diamond-type coil having only one surge ring as a support. Note that the bottom-half coils are lashed to the surge ring, and also that each coil is tied in two places, rigidly affixing together adjacent coils. As the tying progresses from one coil to the other, there becomes a network of ties which rigidly binds the entire end winding. Spacer blocks of canvas-base bakelite or similar material are used between coils at the places of

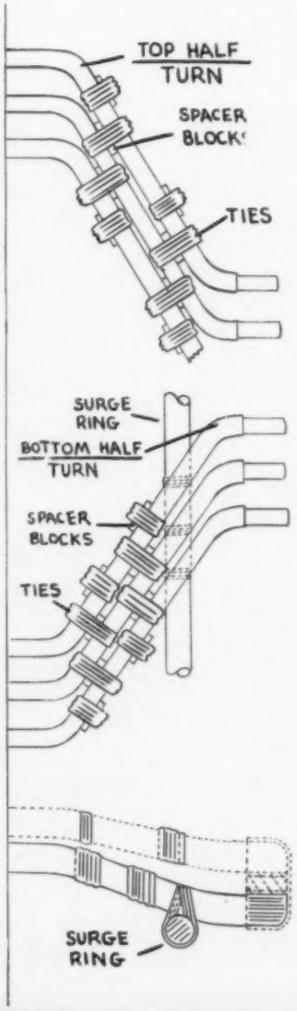
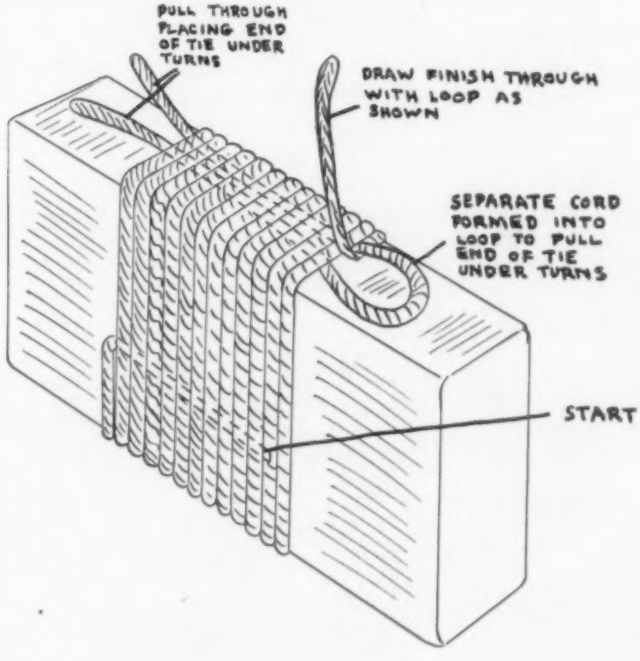


Figure 1 — One method of tying the end winding of a half turn, diamond-type winding is here shown. Note bottom coil is lashed to surge ring, and to the adjacent coils so that the tying progresses from coil to coil. This results in a rigidly braced winding. Spacer blocks maintain a uniform gap for ventilation and are essential to a solid end winding.

Figure 2 — This sketch reveals how a single cord tie is commonly used. The start and finish are anchored down as shown. The start is folded under the required number of ties, and the finish is pulled under the ties by the use of the loop, pulled taut and cut off.


PULL THROUGH PLACING END OF TIE UNDER TURNS
DRAW FINISH THROUGH WITH LOOP AS SHOWN
SEPARATE CORD FORMED INTO LOOP TO PULL END OF TIE UNDER TURNS
START

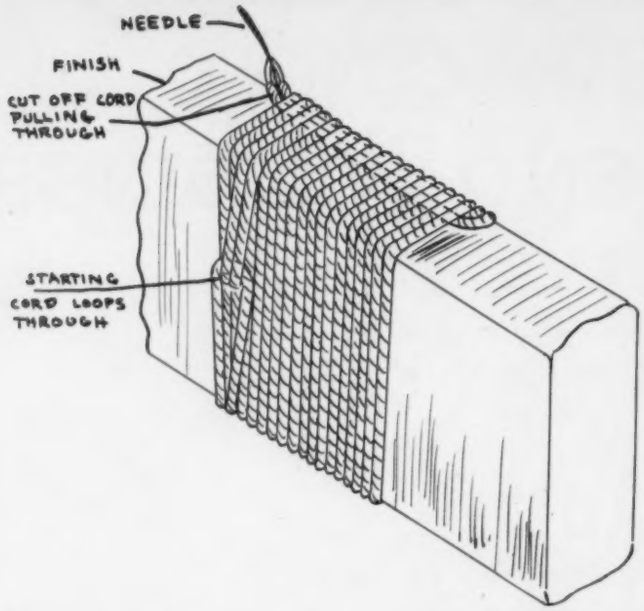
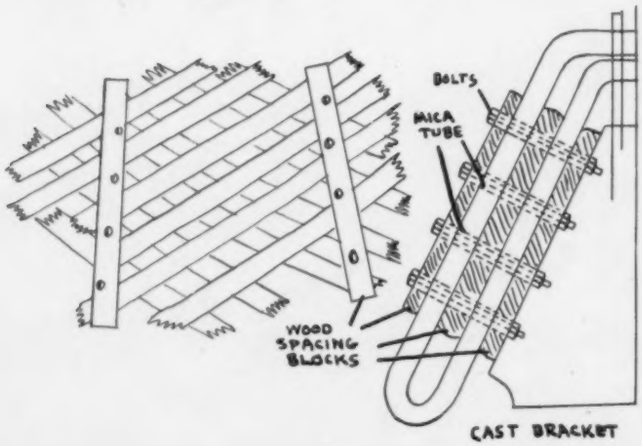


Figure 3 — This double cord tie is used often on larger equipment. A loop is made by tying the ends of a single cord together and then the first turn of the tie is fed through the folded back on itself. After the ties are made, the finish is fed under the ties with the needle, pulled through taut, and cut off.

tying. The top-half coil is similarly tied, but not to the surge ring.

Two commonly used methods of beginning and ending a tie are shown in Figure 2 and Figure 3. Figure 2 shows the start and finish of a single cord tie. The start is folded across where the tie is to be made and, at the same time, a loop is made with a separate piece of cord and placed on top of the coil. The required number of turns for the tie are now made, running over the start and the loop. End of the tie is then guided through the eye of the loop and the loop is pulled through, thus taking the end of the tie and placing it under the turns in the tie. Figure 3 shows the start and finish of a double cord tie. Here the ends of the cord are tied together, forming a loop. The first turn of the tie is then fed through the end or loop and then folded back on itself, and the required number of turns of the tie are then made. The finish of the tie is fed under the turns by use of the steel needle and then pulled taut to the edge of the coil and cut off. The needle can also

Figure 4 — This scheme is used on semi-involute diamond-type winding. Wood blocks are used to space and support the winding. Through bolts are insulated from winding by mica tubes.



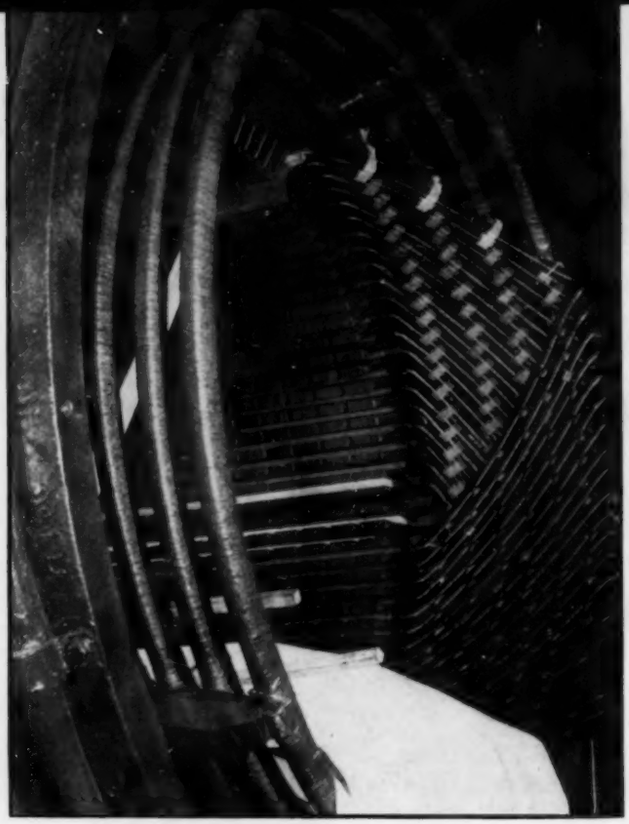
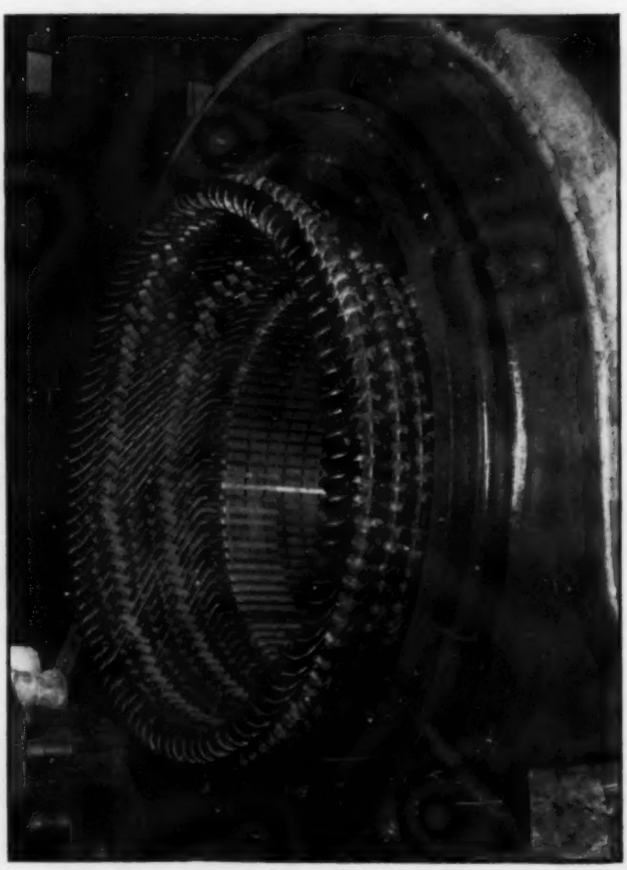


Figure 5 — A method of tying the bottom layer of the end windings of a turbogenerator. Note the four surge rings and that coils are lashed together at the four surge rings. Spacer blocks are placed between coils at each tie, with an extra tie at 90 degrees from the initial tie. This is done to take up slack in the cording.

Figure 6 — Completed winding. Notice that a combination of spacer blocks was placed on the coils at the time of manufacture. Also notice the series of ties made after the winding had been placed in the machine.



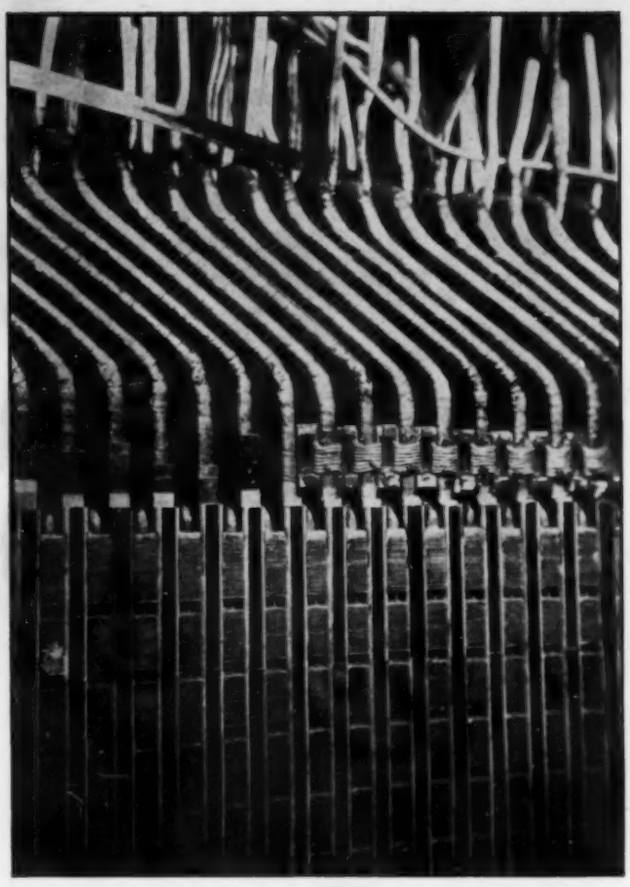


Figure 7 — Where the coil extension is large, additional bracing is supplied by tapered blocks at the end of the core.

be used in the method described in Figure 2 and the separate loop of cord eliminated.

In Figure 4, is shown the method of bracing used in older types of turbogenerators. The coil is a semi-involute diamond, and special cast brackets are bolted to the generator core to which the coils are braced. Wood blocks space the coils in the end turns and bolts are shielded from the coils by mica tubes.

Another method of bracing the end windings of a turbogenerator is shown in Figure 5. Note here, that the bottom end turns are tied to 4 surge rings, and also that two coils are tied simultaneously at each position of tying to individual surge rings. The two coils are separated by maple or bakelite blocks. Top end turns are tied to each other, separated by the same type spacer blocks. This is shown in Figure 6 which shows the completed winding. For the larger machines, supporting blocks are tied between coils at the ends of the core to prevent damage to the insulation. This is shown in Figure 7.

Figure 8 shows the method most commonly used for bracing end windings in induction motors. The surge ring is made of steel and is fully insulated from the coils. Each coil is tied with a number of turns of cord to the ring as shown. In some cases, spacing blocks are taped on coil end turns during manufacture. Blocks put on during manufacture result in a fairly well-supported end winding, but it cannot be made as well-supported as one in which the bracing is done at time of winding. Figure 9 shows another form of surge ring and end bracing. The large ring is made from laminated wood

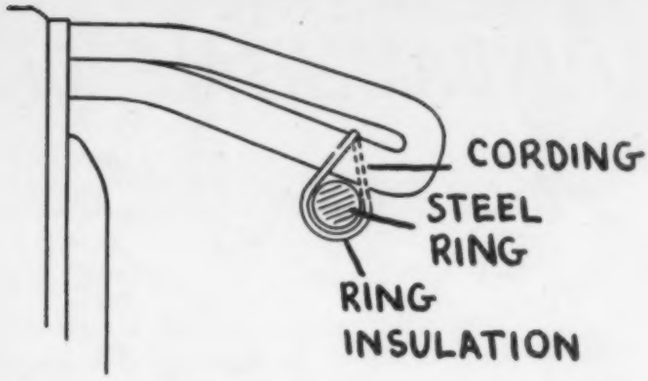


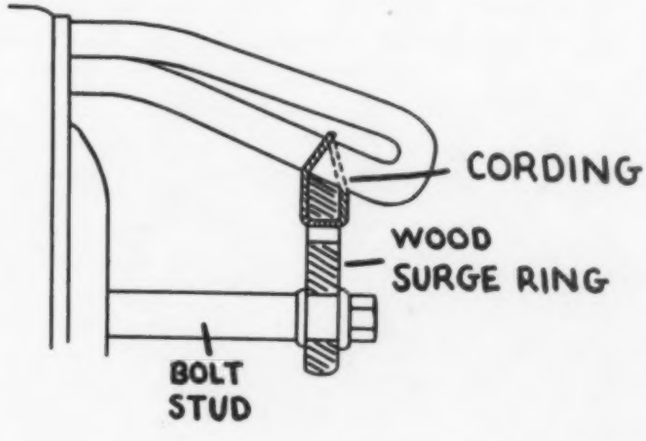
Figure 8 — This method is commonly used for induction motors. The ring may or may not be braced to the motor frame. There are, in some cases, two surge rings. The coils sometimes have spacing blocks taped on at time of manufacture.

assembled so as to have the grain in a number of directions, for strength. It is then bolted to the frame of the machine and end windings tied solidly to it. Bracing between end turns is as described before.

Glass cord and flax cord are both used for making ties. Glass cord is normally available from the usual suppliers as untreated, treated with a light coating of wax, or treated in neoprene. Our company has had the best results by vacuum pressure impregnating untreated glass cord, with a long-life, flexible, slow-baking varnish, and semi-curing it prior to application as tying cord. The varnish impregnation imparts appreciable abrasion resistance to the cord by coating each minute fibre. This also prevents moisture from being entrained between the thousands of small glass filaments. Some users prefer glass cord instead of flax cord, not only because of its better heat-resisting qualities, but because it has been found to be more mechanically stable over longer periods of time.

Flax cord has been the standard material for many years. For the usual job, it is entirely satisfactory. It is easy to use, does not require pretreating and is relatively inexpensive. If thoroughly saturated with varnish after application, it will last many years.

Figure 9 — This system is used for both induction motors and a-c generators. The ring is of laminated wood and bolted to the machine frame. Coil ties are made in the usual manner.



FUNDAMENTALS OF
Annealing Low Carbon Steel

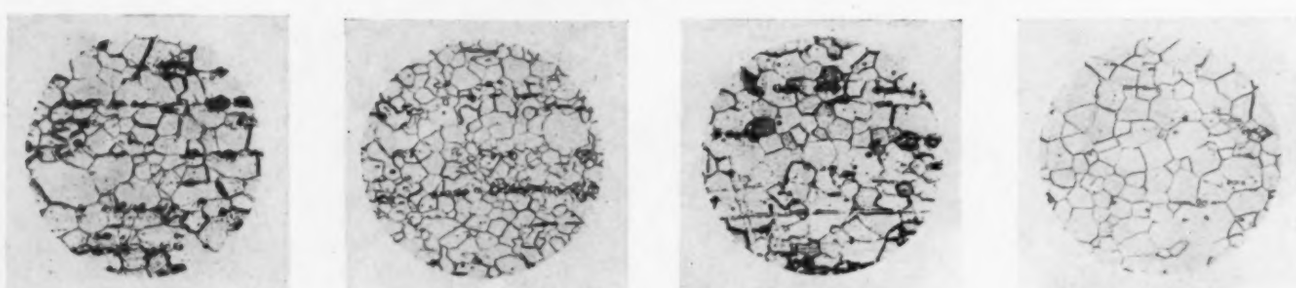
PART II

. . . . supplementing the results of experiments previously described in the 1946 Proceedings of the AISE . . . . this work was done at the Case Institute of Technology under the sponsorship of the Lee Wilson Engineering Company . . . .

By G. SACHS,
L. J. EBERT,
A. W. DANA,
and M. H. JONES
Research Laboratory for Mechanical Metallurgy
Case Institute of Technology
Cleveland 6, Ohio

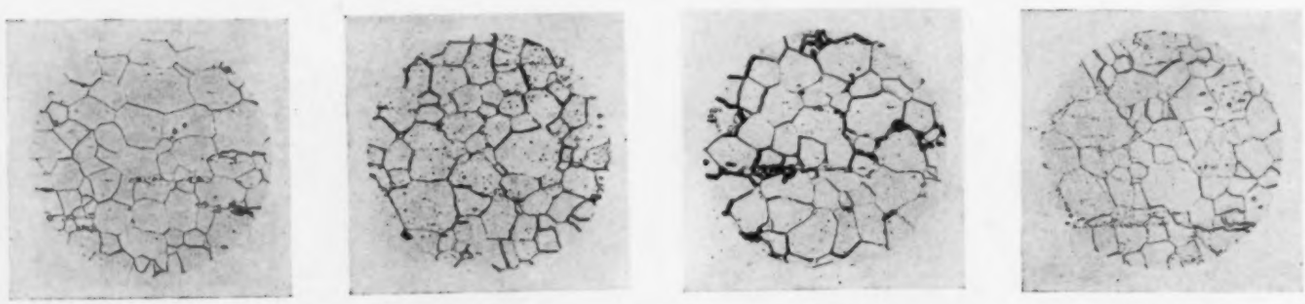
▲ PREVIOUS work on the annealing of rimmed low carbon, steel strip covered the relations between mechanical properties and numerous combinations of annealing temperature, annealing time, and cooling rate. The two mechanical properties most sensitive to slight variations in annealing and cooling conditions were the yield strength and elongation. These, therefore, were chosen as major criteria for determining the

Figure 1 — Low carbon steel strip annealed for 30 minutes at the indicated temperature and furnace cooled to room temperature. Standard process annealed strip added for comparison. (ASTM grain size numbers in parentheses). Magnification 250 X.



Standard Process Anneal (9.9) | 1100 F (11.4) | 1200 F (10.4) | 1250 F 10.0)

Figure 2 — Low carbon steel strip annealed for 30 minutes at the indicated temperature and furnace cooled to room temperature. (ASTM grain size numbers in parentheses). Magnification 250 X.



1300 F (9.7) | 1400 F (9.6) | 1500 F (9.2) | 1700 F (7.5)

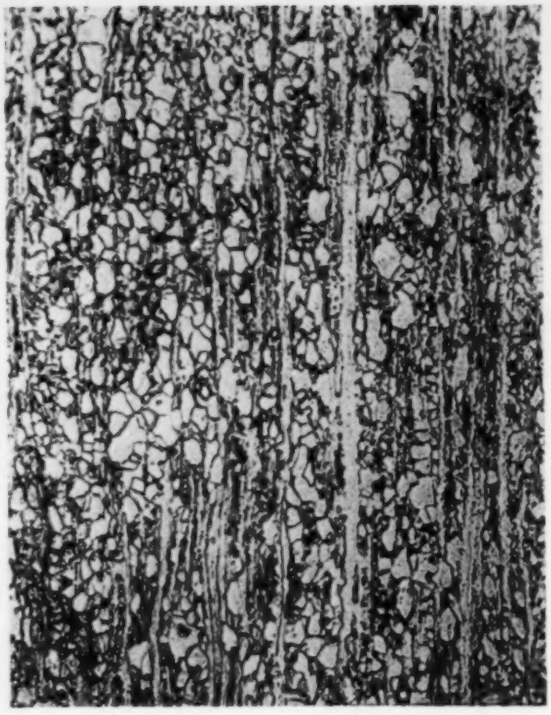


Figure 3 — Low carbon steel strip annealed 30 minutes at 1050 F and furnace cooled to room temperature.

fundamental relations. From the intensive study of these properties, plots were derived, summarizing the relationship between the annealing time and temperature as it affects these properties, the yield strength and elongation. The response to the publication of these results and the application of the data to commercial problems showed the need for similar plots for hardness and grain size, which are widely used in industry for quality control. The data available from the previous investigation have been, therefore, supplemented and are presented herewith to yield summarizing plots on hardness and grain size.

The rimmed steel sheet used in the investigation was of the analysis carbon, 0.09; manganese, 0.45; phosphorus, 0.007; sulphur, 0.026; Silicon, 0.003; chromium, trace; copper, 0.098; molybdenum, 0.02; and nickel, 0.11 per cent. For all annealing times between five and 120 minutes, the specimens were furnace cooled from the annealing temperature at a rate varying from about 10 F per minute at 1200 F to 1 F per minute at 300 F (2 F per minute at 800 F). The hardness data for steel annealed one minute between 1100 and 1325 F, air cooled, reheated to 1000 F and furnace cooled, were also incorporated into the results as this annealing cycle had previously been found to be comparable to furnace cooling. Each plotted point of hardness data is the average of at least ten readings.

The grain size was closely determined by careful selection of representative regions, by the selection of optimum magnifications for counting, and by counting by different observers. The ASTM grain size numbers were calculated from the equation $G = 2N^{-1}$ where G is the number of grains per square inch at one hundred magnifications and N is the ASTM grain size number. A few typical photomicrographs used for grain counting are shown in Figures 1 and 2. No grain counts were made for specimens not completely recrystallized, such as are shown in Figure 3.

For given times, the grain size became larger with

Figure 4 — Effect of annealing temperature for various times on the ASTM grain size of rimmed low carbon steel, furnace cooled from annealing temperature.

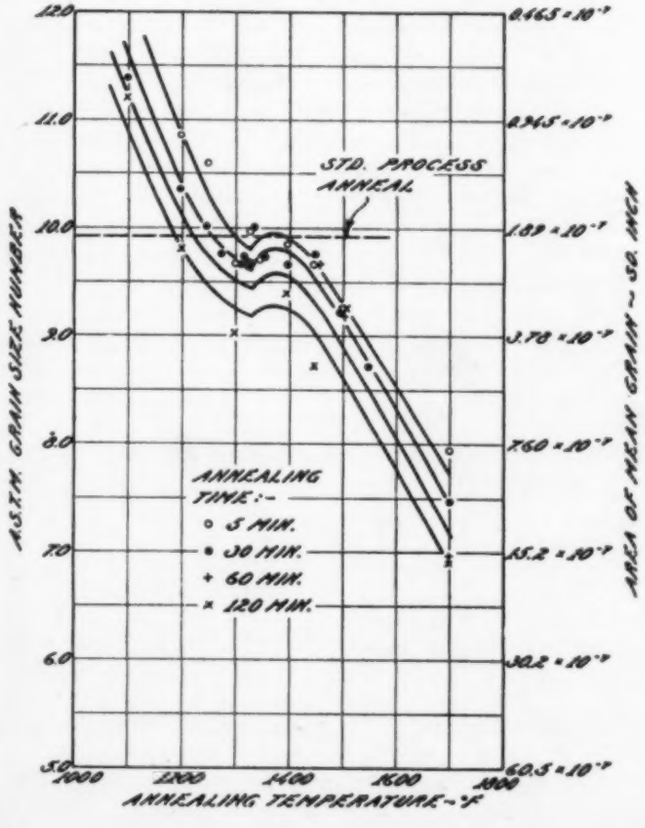
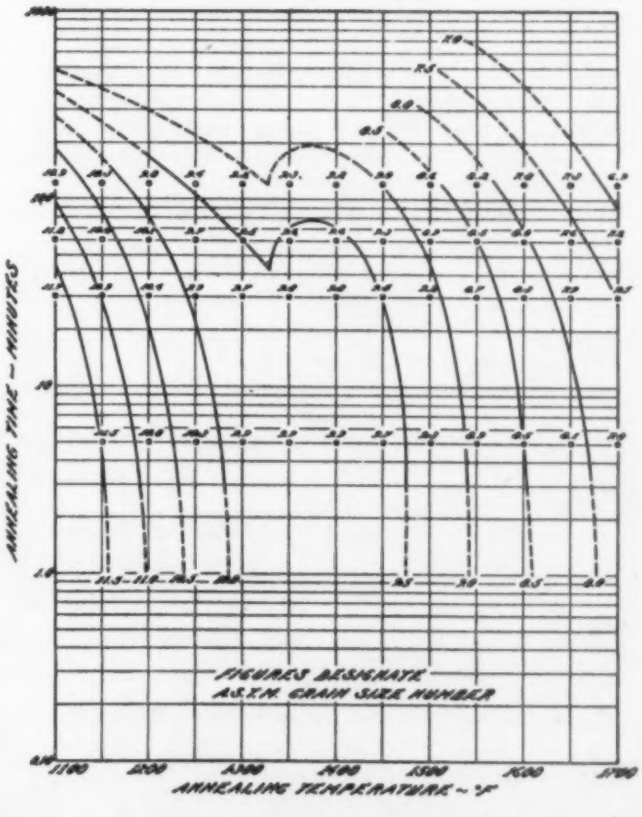


Figure 5 — Relation between annealing time and temperature as it affects the ASTM grain size of rimmed low carbon steel, furnace cooled from annealing temperature.



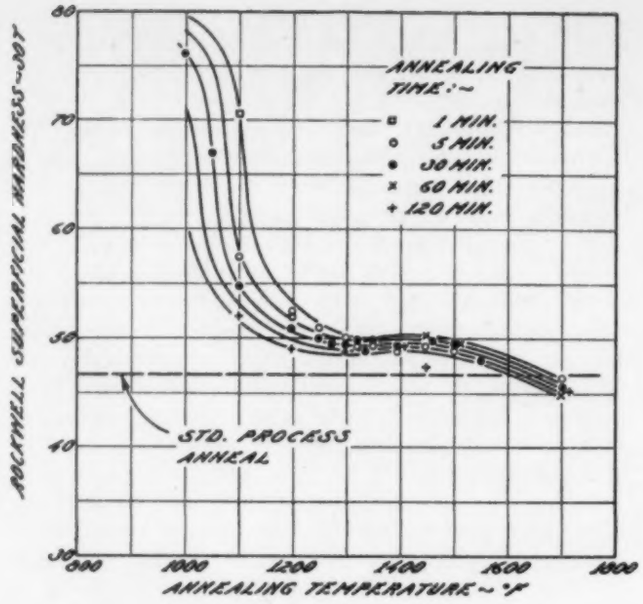


Figure 6 — Effect of annealing temperature for various times on the Rockwell superficial hardness (30T) of rimmed low carbon steel, furnace cooled from annealing temperature.

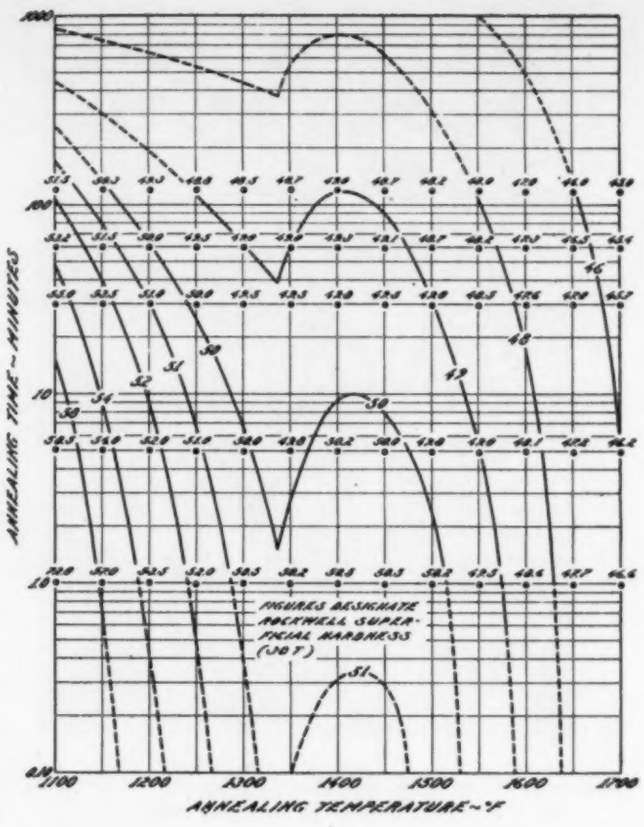


Figure 7 — Relation between annealing time and temperature as it affects the Rockwell superficial hardness (30T) of rimmed low carbon steel, furnace cooled from annealing temperature.

increasing annealing temperatures up to the lower critical temperature of approximately 1300 F, Figure 4. The sharp reversal in the trend curves at this point indicates some grain refinement caused by phase transformation. At about 1400 F, the initial trend again appears to show larger grains for the specimens annealed at higher temperatures. It appears that at 1400 F, the grain refinement resulting from transformation on the one hand, and the grain growth, due to higher annealing temperatures on the other hand, nearly compensate each other. At still higher temperatures the effect of grain growth dominates. The upper critical (A_3 = 1600 F) apparently does not cause any significant change in trend, according to manner of representation. The grain size also increases with increasing time at temperature, Figure 4.

The combined and relative effects of temperature and time are also clearly illustrated by a different representation of the results, in which curves are given for the grain size obtained for various combinations of time and temperature, Figure 5.

The hardness tests resulted, in general, in decreasing hardness with increasing temperature, Figure 6. However in a manner similar to the grain size phenomena, a slight minimum and maximum in hardness 30-T values appear to exist at the temperatures of 1330 F and 1400 F, respectively. In the previous paper, this has been explained by a slight hardenability effect. The combined effects of temperature and time on the hardness, are further illustrated in Figure 7.

The unannealed sheet used throughout this and the previous investigations was cut from the center of a coil which was later process annealed. The properties of the process annealed metal which was adjacent to the test sheet were (lower) yield strength, 35,000 psi; tensile strength, 49,000 psi; elongation, 32.5 per cent in 2 in.; Rockwell 30-T hardness, 46.5; and grain size number, 9.9. All test properties other than the hardness indicated annealing conditions equivalent to approximately 1200 F for two hours. However, the hardness of the laboratory tests made under these conditions gave 2½ points higher results than the process annealed sheet. The small but definite discrepancy in hardness cannot be explained at present. The hardness results, nevertheless, show the relative effects of different time-temperature combinations upon the hardness of mild steel sheet.

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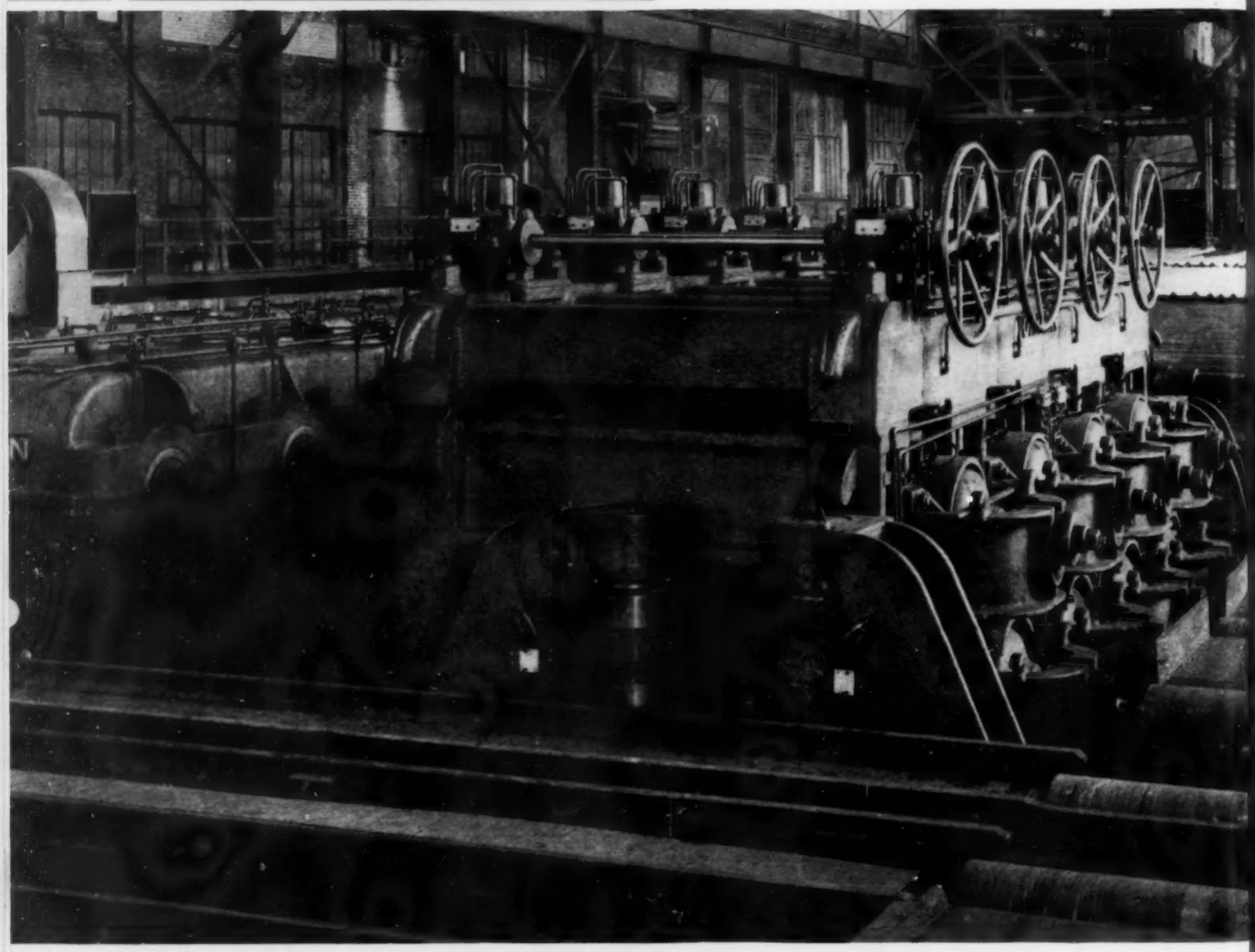

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NEWS SUPPLEMENT JANUARY, 1948

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Iron AND Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

ELECTRICAL AND ALLIED DEVELOPMENTS IN 1947

By GUY BARTLETT

GENERAL ELECTRIC COMPANY

▲ Progress was conspicuous throughout the electrical industry in 1947. There were intense and effective research and engineering studies. In many industries there were trends toward greater use of electricity, use of power reached an all-time high. New records were set for speed, power, or size of equipment. There was a wide variety of new or improved products for industry, commerce, and home. Research, engineering, and manufacturing facilities were still being expanded.

Highlighting the research and engineering studies were, among others, intensive investigations in the field of atomic energy for power production; the production and use of betatrons, synchrotrons, and other atom-smashing machines for probing into the secrets of the atom. Rocket propulsion motors, their contouring, fuels, and controls received much attention. The gas turbine — famed in jet-propelled airplanes—was undergoing exhaustive tests. Looking forward to the day when higher voltages will be required for transmission lines, equipments were being designed, produced and tested for use at 360,000 volts or more. Research and fundamental development in aviation went ahead at a rate comparable with that maintained during the war years.

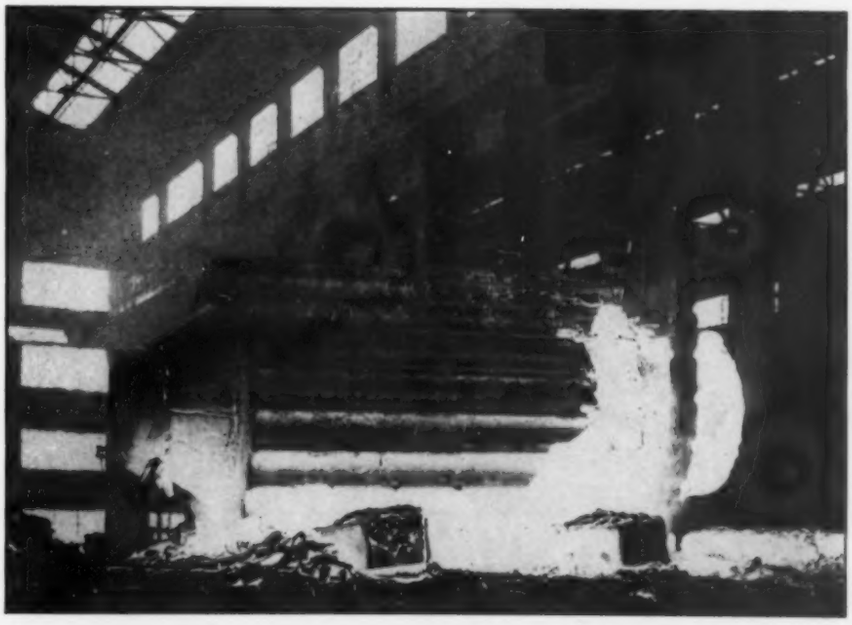
The year had its full share of firsts and largests. There were electric locomotives setting records for both size and power. A transformer was so large its tank had to be shipped in sections. Two of the largest placer dredges ever built were delivered for tin-mining operations. Eight turbojet engines powered the newest giant Flying Wing. There were many particularly large electric motors for industrial drives. Steam turbines were record-breaking not only because of the number which will operate with steam at over 1000 F temperature but also because of their size.

There were numerous industrial trends of importance. The steel industry, for instance, continued to emphasize the need for more automatic equipment, higher speeds, and a greater output per mill or processing unit, to combat rising costs. In rubber mills there was a definite trend to the use of completely electrified drives, using individual motors. Induction and dielectric heating found new advantageous applications; and so did electronic control equipments.

The steel industry continued to emphasize the need for more automatic equipment, high speeds, and a greater output per mill or processing line to combat rising costs and to compete in today's markets. As always, the electrical industry played a major role in this effort.

Hot-strip mills — A new 66-in.

CYCLOTRON MAGNET USES 460,000 LB INGOTS



The yoke and the pole pieces for the 2000-ton magnet of the cyclotron now under construction at Columbia University's new nuclear research laboratory were produced at the Bethlehem, Pennsylvania, plant of Bethlehem Steel Company. The magnet was made of a special low-carbon steel for high permeability quality.

Production of plate of the dimensions involved is not a routine job even in a large steel plant. The rolling procedure used in regular plate production can, of course, not be used for such large members, but they must be shaped on large presses. The press used on this particular job was a 7500-ton steam-hydraulic unit. The ingots used were among the largest ever handled, weighing about 460,000 lb each.

reversing hot-strip mill, for the Pittsburgh area, will be the first completely new installation of its type; two reversing hot-strip mills now in operation were reconverted for such service. The reversing hot-strip mill is an economical tool for the production of hot strip in small quantities.

A 48-in. semicontinuous mill, which went into production in the Youngstown area, has an existing rougher supplemented by two 2500-hp and one 2000-hp finishing stands.

One of the largest a-c mill motors ever built by the General Electric Company will go into operation soon to drive an intermediate roughing stand on an existing semicontinuous mill.

An existing 76-in. hot-strip mill is being equipped with two modern coilers. These coilers, together with the accompanying approach tables, pinch rolls, etc., will be driven by MD motors with amplidyne adjustable-voltage control.

Cold-strip mills — The first tandem mill with individual generators for each stand motor, one of the world's largest and fastest five-stand tinplate mills, went into operation. Stand 5 has twin double-armature driving motors.

A 54-in. four-stand sheet mill for installation in the Chicago area will use individual generators for the main-stand motors as well as for the uncoiler and winding reel. Power is supplied by one 6000-kw synchronous motor-generator set and one 6400-kw synchronous motor-generator set, with amplidyne control of power factor.

A 93-in. three-stand mill, going into production soon, is supplied with power by an unusually large synchronous set consisting of three 3500-kw main generators, one 700-kw reel generator, and one 14,000-hp synchronous driving motor. An existing 42-in. five-stand mill will be speeded up and the power increased by the substitution of a new 2000-hp, 500/900-rpm motor for the existing 1250-hp, 350/790-rpm motor on Stand 5. A 93-in. three-stand mill, originally built with one 1500-hp motor driving each stand, will have an additional 1500 hp added to Stands 2 and 3. A four-stand tandem mill for rolling silicon and stainless steels went into operation during the year.

A new two-stand temper pass mill with twin driving motors on the main stands and delivery puller is now in operation. A regulating tensiometer automatically controls the strip tension between Stands 1 and 2. Amplidyne adjustable-voltage control and amplidyne control of tension are provided.

Processing lines — Processing lines continued to represent a major portion of the modernization and expansion program in the sheet- and strip-finishing industry. It is interesting to note that adjustable-voltage control is now being used almost exclusively for strip processing lines.

Several pull-through pickling lines are being furnished with electronic control of the winding reel which propels the strip through the pickling tanks at a constant preset strip speed. An existing electrolytic cleaning line is being completely revamped and speeded up to a maximum speed of 2500 fpm.

A 54-in. side-trimming line was designed to handle 50,000-lb coils (24 to 72 in. diam) at speeds of 500 to 1500 fpm. The control will either automatically hold loops before and after the trimmer, or run the strip straight through under tension control.

A 54-in. sheet-shearing line will handle 50,000-lb (24/72-in. diam) coils at a strip speed of 200/800 fpm. Photo-thyratron loop control operating in conjunction with adjustable-voltage control is being supplied.

A 60-in. sheet-shearing line is being modernized and speeded up by the substitution of adjustable-voltage control in place of the original magnetic control.

A unique feature of two galvanizing lines is that a new type of d-c motor will be used to cover the wide speed range required. These motors are a modification of the "unit-cooled" motor and are so arranged that one fan circulates air through the air-to-air heat exchanger while another fan circulates air through the motor itself. One small a-c motor drives both fans, and the ventilation is not impaired by low-speed operation.

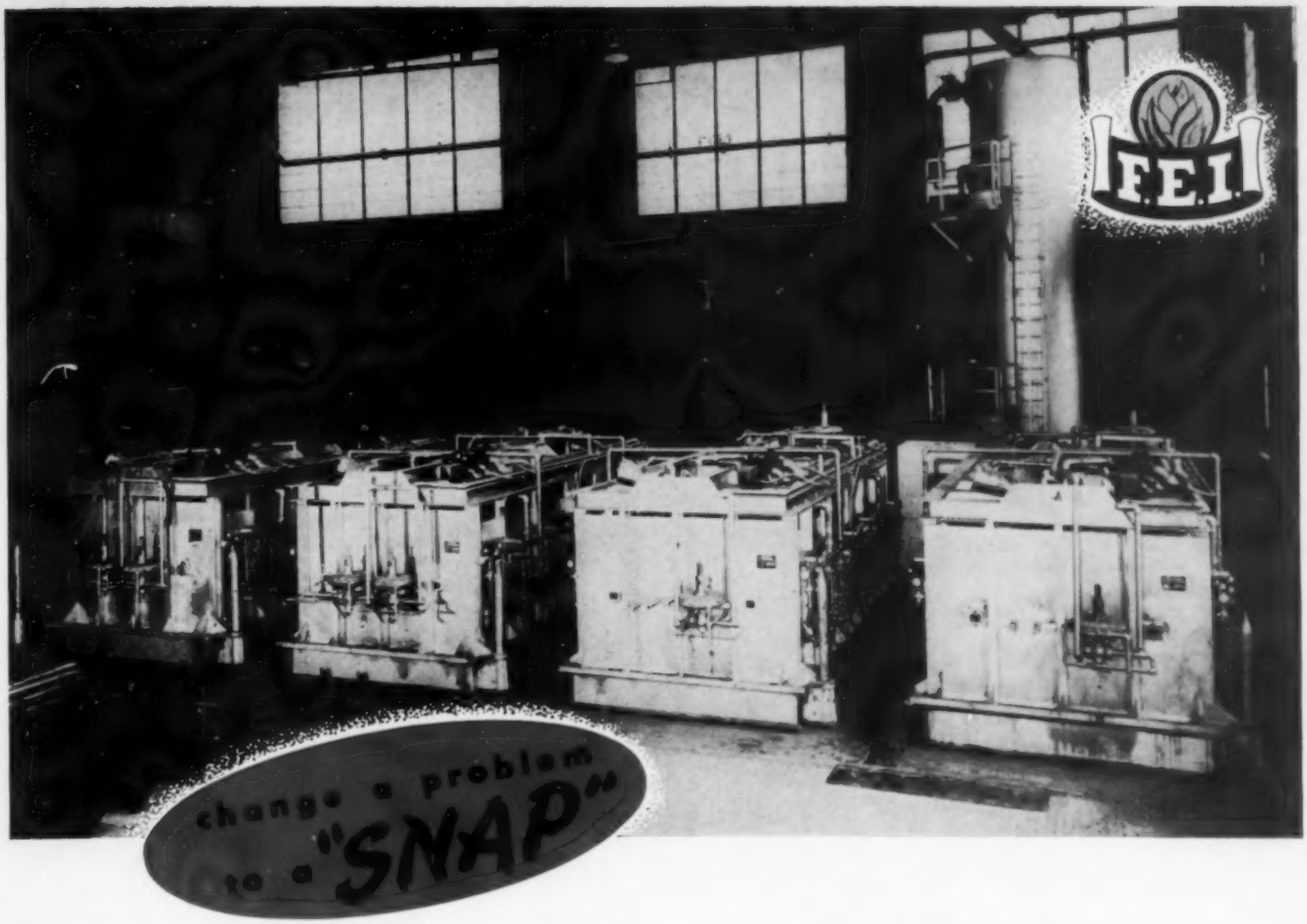
Blooming, slabbing, and breakdown mills — A new 40-in. reversing blooming and slabbing mill will have a 6000-hp 40/100-rpm main drive and a 5250-kw flywheel motor-generator set.

A new 32-in. reversing blooming mill in South America will be driven by a 3500-hp 50/120-rpm d-c motor and a 3000-kw flywheel motor-

BROOKS OIL COMPANY HONORS FAITHFUL EMPLOYEES

Brooks Oil Company recently paid honor to the employees who helped make 1947 the most successful year in the history of the 71-year old company. In making the presentation of gold watches, bonus checks, and gold service pins at the special honorary banquet, Alfred W. Ward, president, emphasized the importance of the security that any company gains from long-service employees.

In recognition of their more than 25 years of service, four of the company's oldest employees were presented with gold watches. Each employee with five years or more service was given a gold service pin or a special award. Mr. Ward is shown above presenting a service pin to F. H. McCurdy, vice president.



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- Continuous Quenching and Tempering Furnaces — Quench Tanks, Water or Oil.
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generator set. Amplidyne adjustable-voltage control will be supplied.

A new edger drive rated 1500-hp 150/360 rpm will be added to an existing reversing blooming and slabbing mill. A 1250-kw synchronous motor-generator set will be used with amplidyne control. This mill will roll slabs for the reversing hot-strip mill mentioned previously.

Other mills — A mid-western steel plant decided to power the roughing train of its existing four-strand rod mill with a new 1750-hp 900/560-rpm Kraemer drive. Study indicated that the Kraemer drive would provide the small increments of speed adjustment so desirable for maintaining a loop between intermediate and finishing trains.

A new 10-in. bar mill was equipped with an electrically operated billet shear. This shear is driven by MD motors and its success is made possible by the use of the amplidyne exciter.

Two new seamless-tube mills are equipped with motors having very special transient speed characteristics. Amplidyne voltage-and-speed regulators are used with electronic control for extreme accuracy.

A 26-in. billet mill was equipped for drive by a 2500-hp synchronous motor. This same motor will be used to drive a motor-generator set used to supply power to a new continuous mill which will eventually replace the present 26-in. mill.

Drawbenches — Activity in the cold-drawing of metal continued at a high level. The main activity has centered around the reversing-chain and rack-type drawbenches. All of these benches use adjustable-voltage control, and this type of control is gaining in popularity for the conventional type benches. The reversing-chain drawbench is designed to eliminate the carriage-return drive.

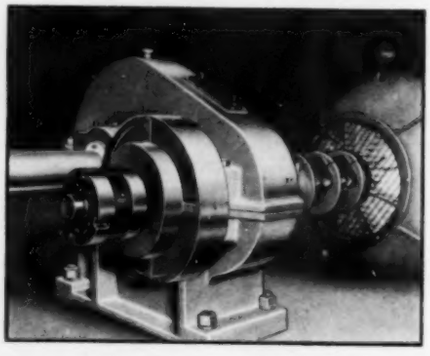
Controls and gages — An X-ray thickness gage developed in the company's general engineering and consulting laboratory was successfully applied for measurement of steel thickness in a hot-strip rolling mill. It measures the thickness to within 2 per cent while the steel is being rolled.

A magnetic side-register control, operating on changes of inductance caused by variations of the steel strip position, was developed to solve the problem of accurately guiding a fast-moving steel strip.

As part of the variable-voltage control system for mills and processing lines where speed, current, or voltage regulation are required, an amplidyne packaged control unit was developed. It is used to control tension on a winding reel of a cold-strip mill.

PRECISE CONTROL NOW BUILT IN A-C CRANE

▲ The greater majority of users have previously chosen d-c cranes because of their better control. However, the use of d-c power always entailed extra d-c power supply. P & H's aim, therefore, was to provide a-c cranes with the same speed load characteristics as d-c cranes. Also, crane builders naturally wish to eliminate the mechanical load brake on a-c cranes. This mechanical load brake has been a source of maintenance and the speed control that was obtained was not very consistent. Therefore, one of the essentials in good a-c hoist control was the elimination of mechanical load brake.



The "all position" dynamic braking generator is shown mounted on the hoisting unit.

Another purpose is to obtain speed control on the various steps of the controller with slight variation between no load and full load, and this is known as a flat speed load characteristic.

Another feature that should be incorporated in good a-c crane control is the ability to handle heavy loads slower than light loads. The load must also raise at all times when the controller handle is in the raise position, and on the lowering side of the control, the load should always lower.

The above results should be met with the use of standard known equipment and without detrimental effects to the motor, or allied equipment.

Mechanical load brake was first

Question: What type of electrical cable for all-around service is being widely used in metal-producing and other industries?

Answer: *Okolite-Okoprene* cables, both single conductor and multi-conductor.*

Question: What kind of performance can be expected of Okolite-Okoprene cables?

Answer: *Millions of feet have been installed over the past 20 years and have proved long-lived.*

Question: Where may Okolite-Okoprene cables be installed?

Answer: *In ducts, or buried directly in the ground, or exposed to the elements.*

Question: Is additional protection needed?

Answer: *No.*

Question: What are some of the advantages contributed by the design of Okolite-Okoprene cables?

Answer: *Absence of tapes, braids or metallic coverings that rot or corrode. Perfectly-centered conductors. Uniform thickness of insulation and of covering. Uniform vulcanization throughout entire cable length.*

Question: What are some of the electrical operating advantages of Okolite insulation?

Answer: *High dielectric strength and moisture resistance. Stable characteristics. Low specific inductive capacity. High current carrying capacity. (75°C. copper temperature.)*

Question: What electrical characteristics are contributed by Okoprene, an Okonite-developed neoprene compound?

Answer: *Additional dielectric strength. Additional ozone resistance. High surface resistance which eliminates charging current drainage from cable surface.*

Question: What physical properties of Okoprene provide operating advantages?

Answer: *Lasting weather-resistance. Resistance to oil and solvents. Resistance to acids, alkalies and corrosive chemicals. Non-flammability.*

Question: How about installation?

Answer: *Okolite-Okoprene cables are simple to handle, splice and terminate. They require no potheads. They resist abrasion, are flexible at low temperatures.*

Question: Where can I find out more about Okolite-Okoprene cable and its relation to my problems of electrical distribution?

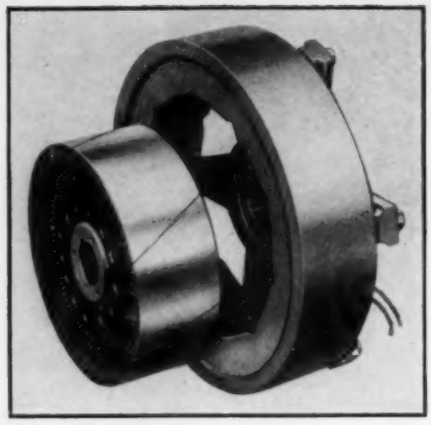
Answer: *By talking things over with a representative of The Okonite Company, Passaic, New Jersey or writing for Bulletin OK-2009.*

* U. S. Pat. No. 2,312,058

eliminated on direct current operated cranes when d-c dynamic braking, with series wound hoist motors, was developed. This introduction took place through the period of around 1910-14. After the introduction of d-c dynamic braking on direct current operated cranes, the speed control obtained on those cranes has become more or less a standard of comparison.

The elimination of mechanical load brake is not new on a-c control. This article shows that the many desirable features long sought by crane engineers, have been developed and incorporated by P & H in the new Magnetorque control. In order to compare P & H Magnetorque control with other schemes, curves shown in Bulletin C-38 will provide such comparison.

Magnetorque speed control characteristics are comparably flat in both the lowering and raising directions. Sufficient torque is developed by the hoist motor on the first step of the controller so that the load will always raise within the capacity of the crane.



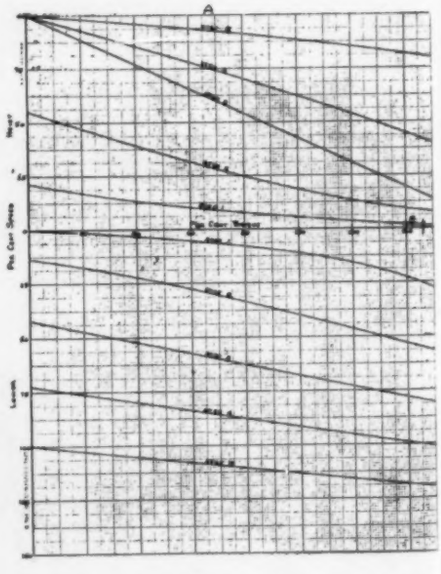
The simplicity of the new a-c crane control is shown here.

This feature is not obtainable in other a-c control schemes, nor is it possible in most d-c dynamic braking control circuits. Therefore, unusual safety of operation is provided.

The heart of the P & H Magnetorque unit is what is commonly known as an eddy-current clutch, or brake. P & H has been using this unit (as a clutch) with phenomenal success on electric excavators since 1942. The units used on excavators, however, are considerably larger than anything that we will employ on an overhead traveling crane. On a crane, this unit is not used as a clutch, but rather as a brake. The hoist motor is directly connected to the hoist drum, through a gear train, and no clutch is involved.

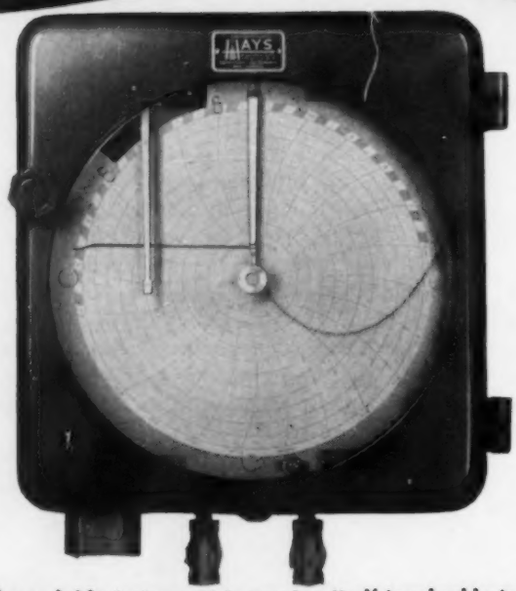
To give you some idea as to the sizes of the unit employed on our

Desirable regulation in both raising and lowering direction is illustrated by these curves for the five steps.



A Practical Means TO CLOSER QUALITY CONTROL

The HAYS "OT" Pressure Recorder



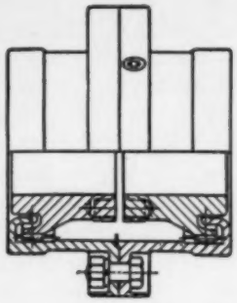
THIS dependable instrument is proving itself invaluable to the steel industry . . for maintaining proper atmospheres in soaking units, annealing furnaces, open hearth furnaces, slab mills, and any place where an accurate record of draft, pressure or differentials is required.

You get an errorless record of two draft values, two pressure values, two differential values, or any combination of two of those values.

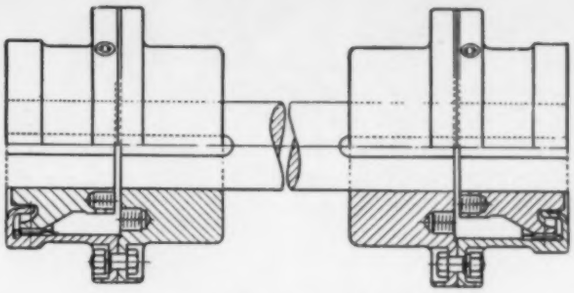
A good many new and modernized open hearth installations are equipped with Hays Series "OT" Pressure Recorders . . . as a simple, dependable, practical means to closer quality control.

Step 1 toward getting the benefits of this modern quality control is to get the facts about it. Bulletin 43-586 tells them . . . better send for it.

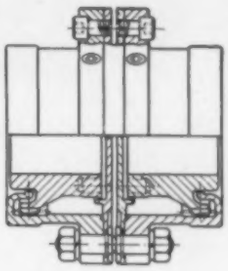
The HAYS CORPORATION
SINCE 1901 COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA U.S.A.



STANDARD



FLOATING SHAFT



BREAKING PIN

WHATEVER YOUR CHOICE . . .

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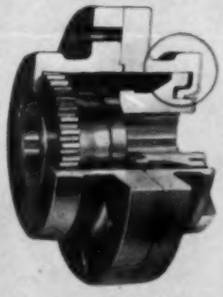
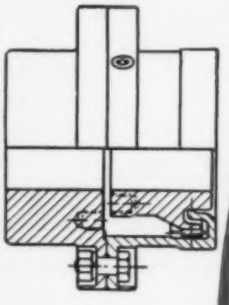
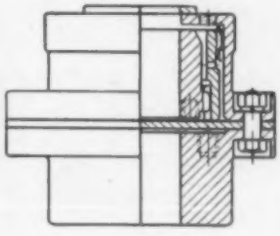


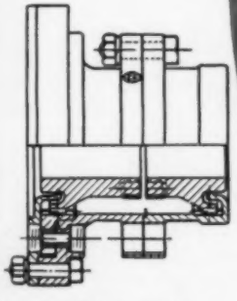
ALL - STEEL CONSTRUCTION! NO PERISHABLE PARTS! Those statements apply to Fast's self-aligning couplings — uniquely designed to give you uninterrupted power transmission. The *exclusive* "rocking bearing" (circled) is an example of Fast's thoroughness. It provides a positive metal-to-metal seal for the load-carrying oil, permanently protecting it against moisture, dust and grit. No perishable packing rings are used. There's nothing to wear, nothing to fail. ¶ Years of engineering experience, Koppers' high standard of workmanship and unexcelled coupling service pay off in longer machine life, lower upkeep costs and minimum shutdown losses . . . when you choose your Couplings from Fast's big, complete line. Prompt delivery. Write for our catalog to: Koppers Co., Inc., Fast's Coupling Dept., 211 Scott St., Baltimore 3, Md.



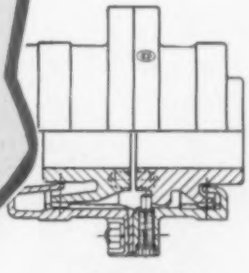
SINGLE ENGAGEMENT



VERTICAL



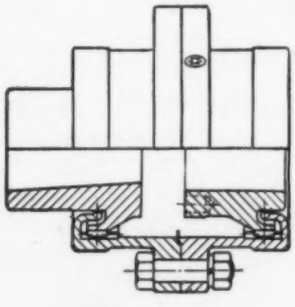
SHEAR PIN



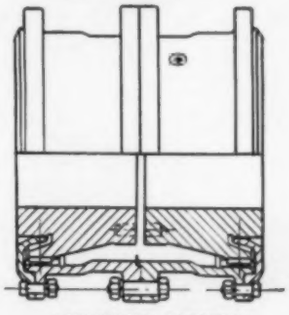
CUT-OUT

K KOPPERS

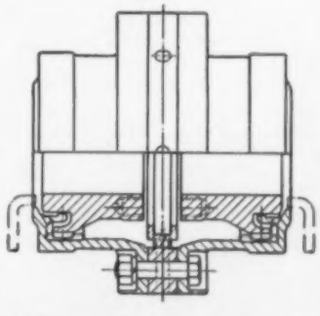
FAST'S *self-aligning* **COUPLINGS**



MILL MOTOR



HEAVY DUTY



CONTINUOUS LUBRICATING

cranes, the unit will be approximately 16 in. in diameter for motors up to 30 hp.

The eddy-current clutch principle will also be used in other fields if current "talk" is correct. For instance, it is understood that the 1948 Ford will have a small 5 in. eddy-current clutch driving the engine fan. In cold weather, the fan will not operate until the engine temperature is at a predetermined point, at which time, clutch will be energized driving the fan. Likewise, at high speeds, the eddy-current clutch will be de-energized, disconnecting the fan and saving approximately 4 to 5 engine horsepower.

Experience with the unit on excavators has been excellent. It has been fool proof and free in maintenance. The crane unit, together with control circuit, has been fully tested over a year on the crane test tower in the experimental department.

An a-c slip ring motor has no speed regulating properties under no load or light load conditions. The motor tends to run at synchronous speed under light loads and even secondary resistance has little or no effect. Speed regulating properties of a slip ring motor are satisfactory only under a normally loaded motor. Therefore, P & H has applied the Magnetorque unit as a brake to provide a load on the motor at all times. In this way full utilization of the better part of an a-c slip ring motor characteristic is used because it is pre-loaded at all times. The load on the motor never exceeds 138 per cent full load current. It is at all times balanced and the higher current is only obtained in the raising direction. In the lowering direction the current never exceeds full load current.

The brake is mounted on the motor pinion extension shaft and the hoist motor is directly connected to the hoist drum at all times. This always provides a positive drive between motor and hoisting unit. The Magnetorque unit consists of a stationary field ring which is bolted to the gear case and centered about the bearing capsule. The indestructible rotor requires no electrical connections and is similar to a rotor in a squirrel cage motor. Since the field poles are stationary and the rotor requires no electrical connections, there are no moving electrical parts. The braking torque is accomplished through magnetic lines of force between the stationary pole ring and the revolving rotor. Therefore, only magnetic lines are broken with the result there is no wear, nor replacement of frictional surfaces. The result is no maintenance. Direct current excitation to the stationary field poles are obtained through a step-down transformer and a selenium rectifier.

The simplicity and the few parts necessary makes this control applicable to be used with either a simple drum control, or full magnetic control. Curve A shows P & H Magnetorque control with full magnetic control indicating 5 steps of regulation in both the raising and lowering direction.

Safety precautions included in this control consists of a current relay connected into the field circuit. This insures energizing the unit before the motor directional contactors can be energized. Failure of current in the unit will result in opening of this current relay, automatically disconnecting the hoist motor from the line and immediately setting the electric motor brake.

When desired, an all-position dynamic feature is available. This feature consists of a small auxiliary self-

(*Please turn to page 113*)

GIANTS in the world of Water Pumping

Peerless Hydro-Foil MIXED FLOW Pumps

CAPACITIES: UP TO 220,000 G.P.M.
LIFTS: 2 to 60 FEET

Rapidly Move and Remove Vast Volumes of Water Against Low and Medium Heads

Highly successful in the efficient handling of large volumes of water, Peerless Mixed Flow Pumps are being applied to process work, condenser service, liquor and chemical circulation and a variety of industrial services where pumping is desired from open pits, sumps, and surface water sources, such as lakes, rivers, etc. and for large scale dewatering operations.

Peerless has proved the effectiveness of incorporating aero-dynamic streamlining principles to large-volume water lifting, resulting in new conceptions of high efficiences and lower overall pumping and maintenance costs.

Water turbulence accompanying the usual propeller and vane construction, and normally resulting in excess wear, inefficiency and loss of power, are reduced to the minimum in the Peerless Mixed Flow design.

Cutaway view of Mixed Flow multi-stage pump impeller and bowl construction revealing high-efficiency impellers utilized for more economical water lift.

Peerless Propeller Type Pumps

Peerless pumps, embodying the Hydro-Foil principle, are also available in the propeller type and are capable of handling identical capacities of the Peerless Mixed Flow pump. Request Bulletin B-148 completely describing the design, construction and application data of these two outstanding types of Peerless Pumps, for large-volume water pumping.

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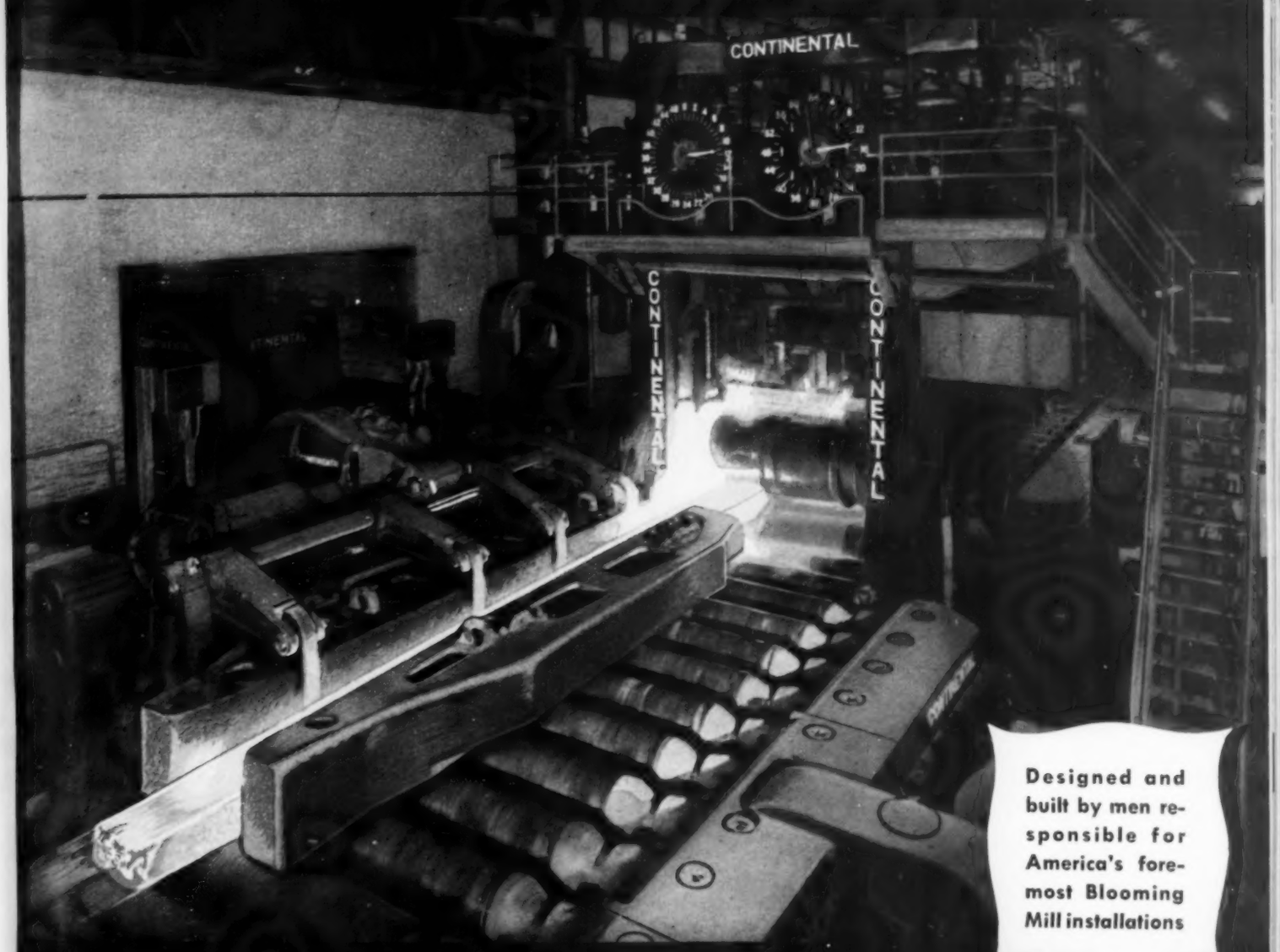

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Q- what single brush gives double brush advantages?

A- *See Speer!*

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These, plus other operating and maintenance advantages, come with the use of Multiflex Brushes because of their inherent simplicity of design. A simple hammer plate attached to one section and overlapping the other, assures equalized spring pressure.

Simplicity of design for attaining increased efficiency in AC and DC motors and generators is only one of the many characteristics of all Speer brushes.
Let Speer match brushes—mechanically and electrically to your machine and provide the right solution.

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(*Continued from page 110*)

excited generator mounted on the unit. Regardless of controller position, ("off" or any "running" position,) the load cannot drop or gain excessive speed in case of power and electric motor brake failure. When the descending load overhauls the hoisting unit, it starts the generator action to excite the unit, thereby retarding the load to safe lowering speeds. This generator is open circuited under normal operation and is only inserted in the circuit when the main line disconnect switch is open, or in the case of power failure. This all-position dynamic braking feature is similar to the dynamic braking safety feature obtained on d-c cranes, equipped with series wound motors. This all-position dynamic braking feature, therefore, provides the same safety as the time tested d-c dynamic braking circuit which has been looked upon, by all, as providing the best speed regulation and the safest crane control system. P & H, therefore, has, incorporated the best features of d-c dynamic braking in the new Magnetorque control making the use of a-c power cranes more desirable. The use of a-c provides a cheap source of power and eliminates the maintenance of motor generator sets while the Magnetorque control provides a fine speed control. This accuracy of control is an essential for powerhouse, machine shop, foundry and other crane application where, heretofore, d-c powered cranes only could be used.

1947 TRENDS . . . . . NICKEL

▲ World deliveries of Canadian nickel in all forms for the year 1947 will be in excess of those of 1946, although considerably under the peak war-time high reached in the year 1943, Robert C. Stanley, Chairman and President of the International Nickel Company of Canada, Ltd., stated in a review of the nickel industry.

"Canadian nickel deliveries this year in all markets will approximate those of the industry's greatest peacetime year of 1937, and shipments in the United States and Canada will show an increase of about 50 per cent over 1937," Mr. Stanley continued.

"The largest consumer of nickel during 1947 continued to be the steel industry. Production of nickel-chromium stainless steels in the United States accounted for a major portion of this consumption. The applications of nickel-containing stainless steels in the various industries continue to be numerous and diversified. The chemical, petroleum and transportation industries remain important users of stainless steels. Popular and well-known uses are in such home appliances as sinks, refrigerators and deep freezers, as well as cooking utensils. Likewise, stainless steels serve in industrial and restaurant equipment for the processing and handling of foods and beverages.

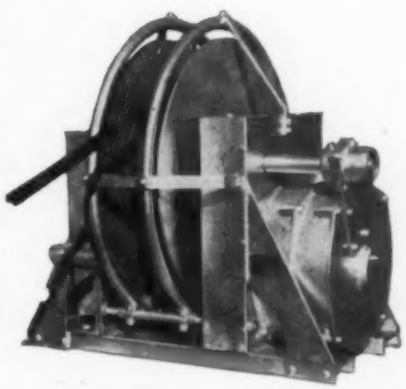
"The so-called triple alloy steels, containing nickel, chromium and molybdenum, continued to be extensively employed this year, particularly in the automotive, construction, railroad, tractor and machine tool industries. Their tonnages, as in 1946, were again the largest of any single class of engineering alloy steels. Two notable applications of comparatively recent origin for these alloy steels have been for structural aircraft tubing, and for hot coiled and leaf springs by the railroad, automobile and tractor fields. Nickel-chromium and nickel-molybdenum steels of the prewar standard types have also re-established salient positions in industry.

"Of great interest is the growing utilization of high strength low alloy steels. The majority of these steels contain nickel and now contribute materially to the over-all consumption of nickel by the steel industry. They are used principally for engineering applications to permit appreciable reductions in deadweight. Industries which have found their use of advantage include transportation, materials handling, earth moving and heavy equipment.

1947 TRENDS . . . . . ALUMINUM

▲ The nation's aluminum industry, now entering its 60th year, topped all previous peacetime production records in 1947. The past year also completed a decade in which the highly-competitive light-metal industry enjoyed a greater growth and diversification

A NEW LINE OF
EXTRA HEAVY DUTY
GLEASON CABLE REELS



SM SERIES

Spring Driven Geared Reel
For Electric Cables
125 Amps — 600 Volts
Continuous Contact
All Ball Bearings
Two-way Payout
Non-Revolving Springs
Fabricated Steel
Watertight
Replaceable Spring Motors
Adjustable Tension
8 Standard Sizes

These reels were developed to meet the unusually severe operating conditions found throughout the steel industry and are of exceedingly rugged construction.

The spring motors are interchangeable and removable so they may be replaced without handling loose springs. Replacement springs are supplied by the factory already installed in the housings and the replaced housings are returnable for credit.

The springs are wound on extra large hubs to minimize flexing at that point.

Adjustment of the spring torque is accomplished by means of a crank handle which is removable. A lock is provided to hold the drum in position during spring adjustment.

Improved current collector and brush rigging, with extra wide spacing, minimizes the possibility of electrical troubles.

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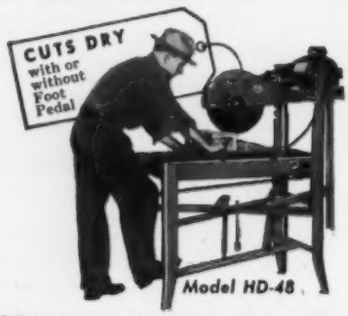
FASTER CUTTING

WET or DRY with the NEW HD 48 CLIPPER Masonry Saw

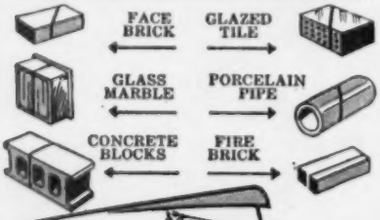
You'll be amazed how quickly and easily you can cut virtually any special length or shape from the hardest masonry materials. Clippers save time — save material, assure better workmanship on every job.



With the exclusive Clipper design, proven throughout the world and guaranteed to provide the fastest cutting speed and the lowest cutting costs.

DUSTLESS MASONRY CUTTING so fast and easy. Just turn on the circulating water system and slice through the hardest masonry materials. Foot Pedal control for varying material sizes or lock the cutting head at a set position, whichever is desired.

CLIPPER MAKES THESE CUTS IN SECONDS



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than in any comparable period of its history.

Ten years ago, on the occasion of the 50th anniversary of the founding of the industry, it was pointed out that aluminum, directly or indirectly, gave employment to about 200,000 persons in the United States. Today, close to 1,000,000 people earn their livelihoods either through the manufacture of aluminum, or by making products in which aluminum plays an essential part. Over the same span of years, the list of known commercial uses for aluminum has grown from around 2000 to approximately 4000.

On the basis of preliminary figures published by the U. S. Bureau of Mines for the first nine months of 1947, it is estimated that actual production of primary aluminum by the whole U. S. industry during the year will be approximately 1,140,000,000 lb, as compared with 819,260,000 lb in 1946, the greatest previous peacetime-year record, for an increase of more than 39 per cent.

HEYL AND PATTERSON ACQUIRES SAMPLER FIRM

▲ Heyl and Patterson has acquired the patents and business of Thorsten Sampler Company. The Thorsten automatic sampler obtains samples of material automatically at predetermined short intervals continuously during the operation of the material handling equipment. The Thorsten crusher, crushes the samples, again takes samples of the crushed material, pulverizes the samples and obtains a final sample from the pulverized material.

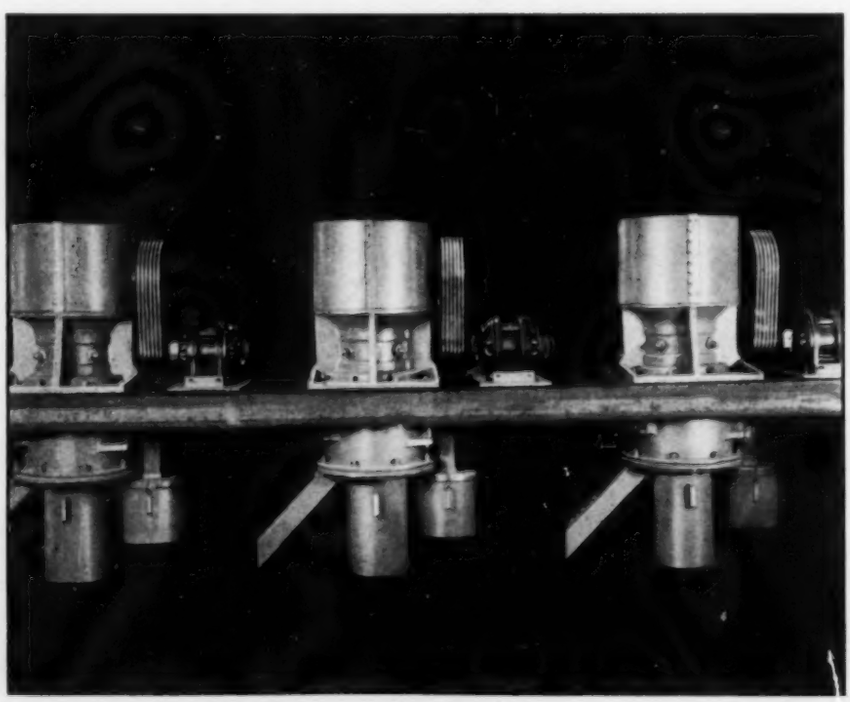
The sampling apparatus is adaptable to any existing conveying system and can be used with belt or flight conveyors or chutes. Installations have been made for crushed coal, run-of-mine coal and ore.

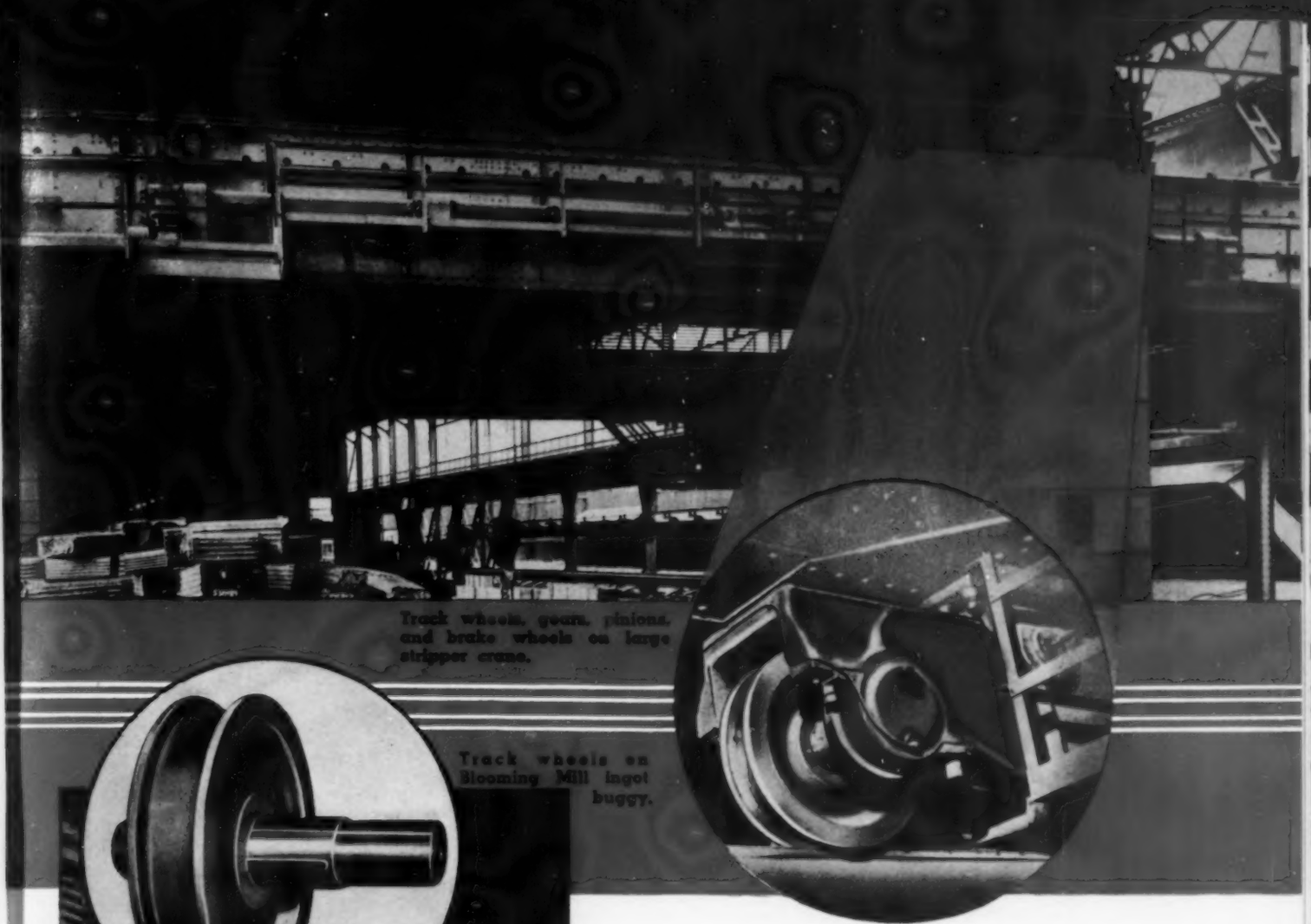
The accuracy of the sampler has been repeatedly demonstrated by many users. The crusher has been tested by one of the largest coal companies, with the tests showing that the analyses of the samples and the surplus material are identical. These samplers have been installed in many of the largest power stations in the United States.

Heyl and Patterson has also acquired the exclusive right to make and sell the Kinney mechanical car unloader, designed by S. P. Kinney Engineers.

The purpose of the car unloader is to facilitate the unloading of hopper cars, particularly in the winter time when the material being handled is partially frozen. The unloader con-

This sampling apparatus is adaptable to any existing conveying system.





Track wheels, gears, pinions, and brake wheels on large stripper crane.

Track wheels on Blooming Mill ingot buggy.

"TOOL STEEL" PROCESS

TRACK WHEELS

the standard for long life

Both operators and maintenance men have learned over a period of time that no other track wheels can match the long, continuous service life of "Tool Steel" track wheels!

A "Tool Steel" track wheel installation means literally years of trouble-free life as against an expectancy of months for ordinary wheels, in the same punishing service.

Write today for complete information.

"TOOL STEEL" PROCESS *The Standard of Quality*

for GEARS • PINIONS • SPROCKETS • WHEELS *and other* HARDENED PRODUCTS

THE TOOL STEEL GEAR & PINION CO.

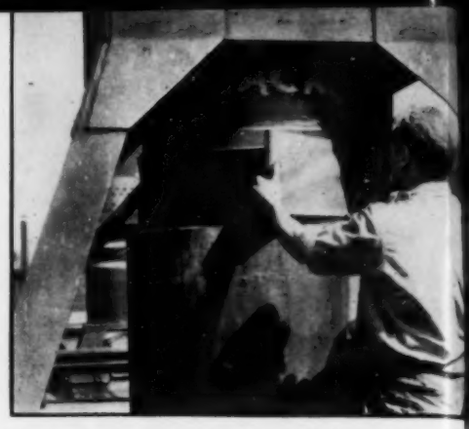
CINCINNATI 16, OHIO, U. S. A.

sists principally of a movable bridge equipped with a trolley which carries an unloading ram. This unloading ram functions as a "giant hand" in unloading the car. The bridge is of a special design to fit local conditions, and may be run on a crane runway, or other suitable type of bridge structure for operation over one or more tracks. The unloading ram is powerful enough to drive through any pile of material in a hopper car. The unloader is particularly suited to unloading sticky or frozen materials.

FIBERGLAS TAPE USED AT ACME STEEL PLANT

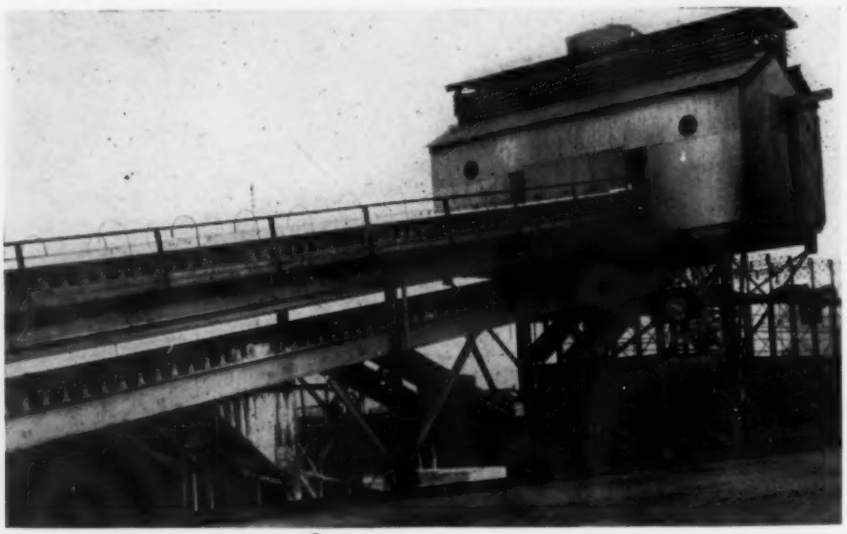
▲ Flexible duct connectors, as employed in a wide variety of industries, are subjected to corrosive fumes and other severe service conditions. Long life on such applications is highly desirable, but not always easily obtainable.

The Acme Steel Company, Chicago, Illinois, has successfully employed Fiberglas-backed industrial adhesive tapes and rubber-coated Fiberglas fabric to replace other materials which proved unable to stand up for more than short periods, or which for other reasons proved less than satisfactory.



The type and fabric are easily installed and will last longer than substitute materials.

At the Acme Steel Company Riverdale, Illinois, plant, blowers connected with large stacks, 24 in. in diameter and 20 ft high, carry off sulphuric acid fumes from vats used for pickling sheet steel. The flexible duct connectors regularly rotted out in less than three months.



Bailey HEAVY DUTY STATIONARY WHEEL PIG CASTING MACHINE

- SINGLE OR DOUBLE STRAND
- LOW POWER CONSUMPTION
- EASILY LUBRICATED
- EXCEEDINGLY HEAVY AND RUGGED

Simplicity of design, high quality of materials, lack of rolling friction and fewer moving parts all contribute to the long life and freedom from maintenance of the Bailey Pig Casting Machine. Moulds are supported on a chain which rides on stationary roller-bearing wheels and around 6½ foot sprockets at either end. Including our improved Spill Proof Pouring End. *Write for complete details.*

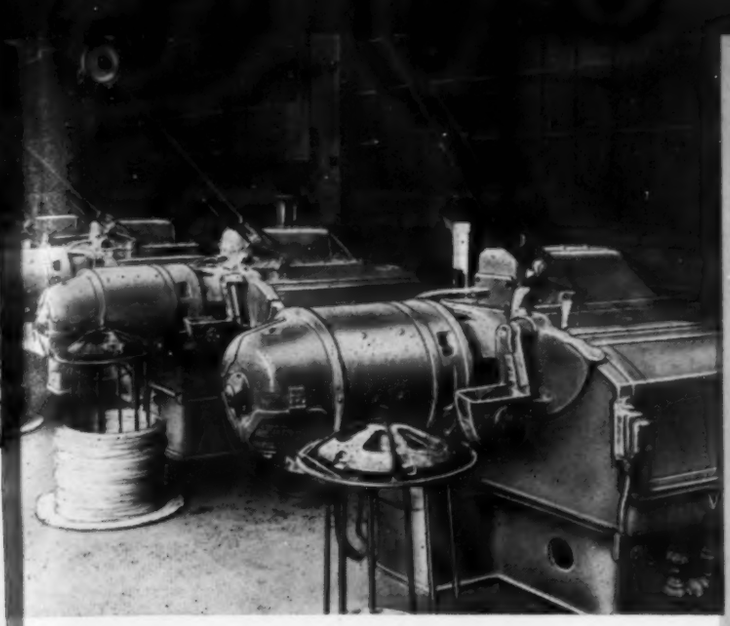
WILLIAM M. Bailey COMPANY
ENGINEERS
LEADERSHIP THROUGH QUALITY
PITTSBURGH PENNSYLVANIA

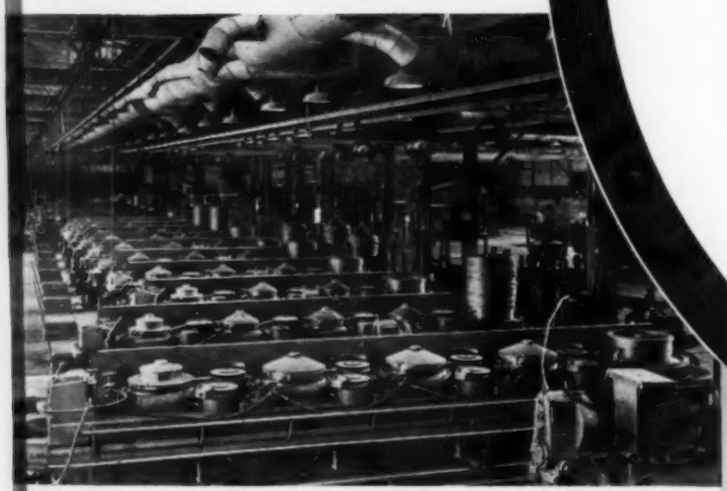
KOPPERS TO BUILD CHILEAN STEEL MILL

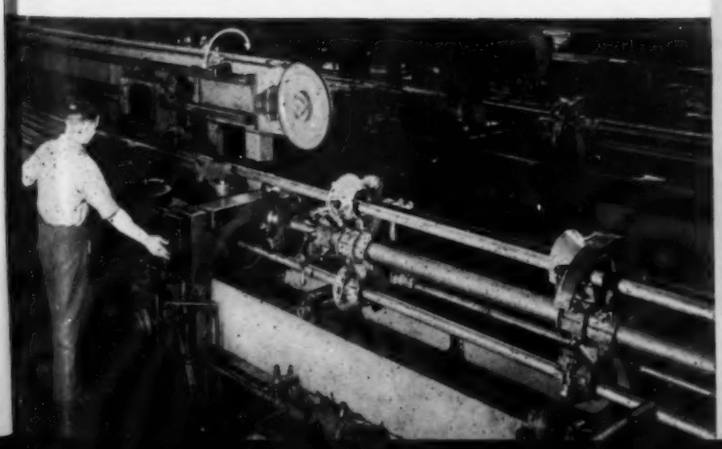
▲ Koppers Company, Inc., and Compania de Acero del Pacifico of Chile (Pacific Steel Company) announced the signing of a basic contract by which Koppers will have supervision of construction, engineering, and management of the first integrated steel plant to be built in Chile. The new facilities will be erected at Concepcion, Chile, on San Vicente Bay at a cost of excess of $50,000,000.

In anticipation of final contracts, clearing of land already has been completed and foundation work started. The entire plant is expected to be erected and in operation by the end of 1949. Construction will be financed partly by Chilean capital and partly by the Export-Import Bank, U. S. government organization formed to aid in financing foreign developments.

Joseph Becker, vice president and general manager of the Koppers Company's engineering and construction division, announced that W. C. Snyder, Jr., vice president in that division, will be Koppers' management representative at Concepcion,







Here's Cold Precision

for your most varied production requirements!

Vaughn

Cold Drawing Machinery

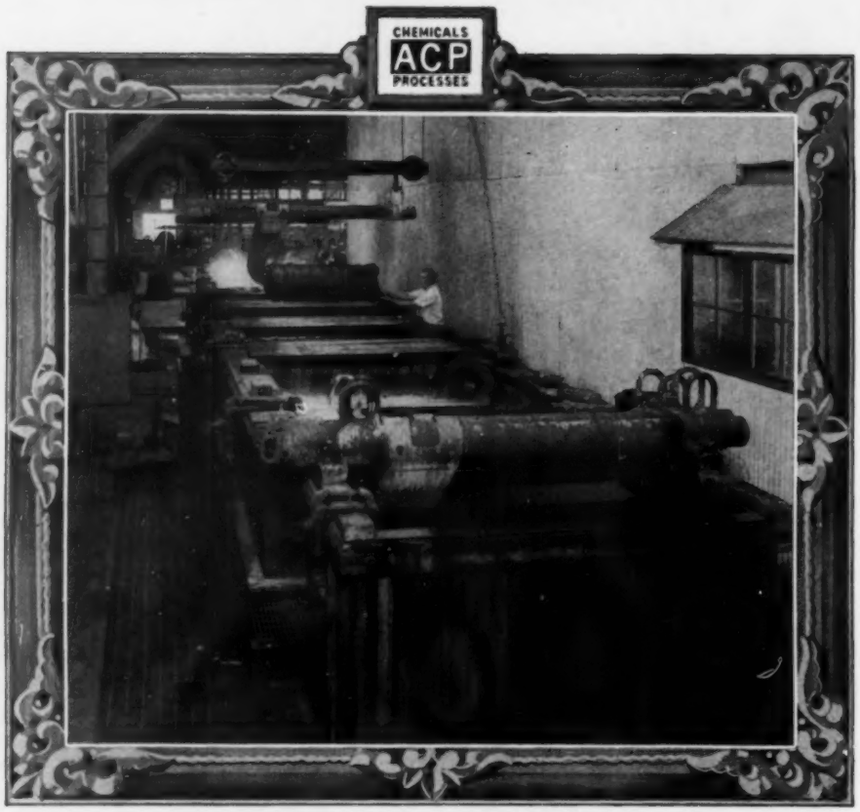
Vaughn's relentless precision in engineering and manufacture assures unfailing machine dependability under your most exacting production schedules. *We'll be glad to detail the facts!*

THE VAUGHN MACHINERY COMPANY
CUYAHOGA FALLS, OHIO, U. S. A.

COMPLETE COLD DRAWING EQUIPMENT . . . Continuous or Single Hole . . . for the Largest Bars and Tubes . . . for the Smallest Wire . . . Ferrous, Non-Ferrous Materials or their Alloys.

VAUGHN MACHINERY
Profitably Used by Leading Producers Since 1871

Picture of Progress



Straight Line Rod and Wire Pickling

Photograph by courtesy of the Buffalo Plant, Wickwire Spencer Steel, Division of the Colorado Fuel and Iron Corp.

EFFICIENT PICKLING WITH *Rodine**

CHEMICALS ACP PROCESSES

RUST PROOFING AND PAINT BONDING
Granodine *
Duridine *
Alodine *
Lithoform *
Thermoil-Granodine *

RUST REMOVING AND PREVENTING
Deoxidine *
Peroline *

PICKLING ACID INHIBITORS
Rodine *®

"RODINE" means efficient control when a small quantity is added to sulfuric or muriatic acid pickling baths. It inhibits acid attack on bare metal and facilitates scale removal.

"RODINE" reduces the hazards of over-pickling and attendant hydrogen embrittlement—assures better pickled surfaces—improves working conditions—and saves acid by prolonging the life of the bath.

There are various grades of "RODINE"—and there's one to fit your requirements. We invite your inquiries.

AMERICAN CHEMICAL PAINT CO.
AMBLER PENNA.

and will have overall supervision of the entire project.

The new Chilean facilities are expected to produce 250,000 tons of finished steel products per year. The plant is designed to use Chilean ore and Chilean coal.

Contracts provide for five integrated parts of the installation as follows: coke ovens to make coke for the blast furnaces and auxiliaries for handling tar and light oils; equipment to purify the coke oven gas and a gas transmission line to serve industrial and domestic users; construction of a blast furnace; construction of steelmaking equipment, including an open hearth furnace, a bessemer converter, and an electric furnace; and finishing mills to produce a wide variety of flat-rolled and merchant products.

Under the contract Koppers Company, Inc., will have supervision of the project, involving the design, selecting of necessary top personnel, purchasing, construction, and operation for an indefinite period which may run as long as 20 years. Koppers' engineering and construction division will design and supervise construction of the coke oven plant. The ovens will be of the Koppers-Becker type, with under-jet firing and recirculating equipment.

The plant will be located on a bay, affording a deep water harbor for shipping, but the supply of water to be used in the plant will come from the nearby Bio Bio river which is fed by melting snow from the Andes mountains. Power will be furnished by the Chilean Government's hydroelectric power distribution system, but there will be standby generating equipment in the plant for emergency use.

NEW SELECTOR INCREASES RECORDER'S EFFICIENCY

▲ Surface Combustion Corporation has just announced the availability of a new selector for atmosphere gases which greatly increases the effectiveness of the "Surface" dew point recorder by enabling it to analyze consecutively atmospheres from as many as six different sources — generators, furnaces, etc., in timed sequence.

The atmosphere selector consists

this cable won't quit when jobs are HOT!

Wiring in high-temperature locations is vital to steady plant operation. If a power cable quits, if a control circuit fails, it may ruin a "heat" or close down a department.

For years, plant engineers with hot jobs to wire have specified Deltabeston* power cable and boiler-room wire. They recognize the practical application experience which General Electric has been able to put behind them. They know that new research is always under way.

In many cases, too, it's the selection of the right *type* of heat-resistant cable that's so important to long life. The Deltabeston line includes standards and "specials" for every combination of heat, moisture, corrosive vapor or other condition. And *men who know the problem* stand back of your Deltabeston supply source, ready to advise you or your contractor on selection. For full information on Deltabeston cables or wires for *any* hot job, write Section Y53-146, Appliance and Merchandise Department, General Electric Company, Bridgeport 2, Connecticut.

**Trade-mark Reg. U. S. Pat. Off.*

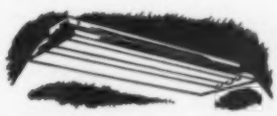
GENERAL ELECTRIC

HI-AMBIENTS

Practical product suggestions from your Deltabeston Distributor

FOR FLEXIBLE LEADS . . . on heavy apparatus that involves hot work, such as electric furnaces, cranes handling hot metals, and the like, Deltabeston YK-2253 is a popular choice. Insulated with an impregnated wall of felted asbestos and asbestos braid, it resists heat, flame, oil and corrosive vapors up to 125 C (257 F).

IF YOU ARE PUZZLED . . . as to the relative merits of asbestos-insulated versus glass-insulated magnet wire for any particular application, you can get unbiased advice from Deltabeston application specialists. The Deltabeston line includes both. And for extra severe jobs, glass-insulated wire with *silicone varnish* is now becoming available. Its rating is 200 C.



FLUORESCENT FIXTURES . . . need heat-resistant wiring in and around the ballast. For those located in hot, humid places, *all* the wiring should be heat resistant. Why not make your installation with the same type of Deltabeston wire which ballast and fixture manufacturers use?

WIRING JET PLANES . . . may be a long way from your business, but the choice of a Deltabeston Aircraft Wire for this extra-severe duty helps explain why so many folks turn to us for solutions to "impossible" insulation requirements.

DELTABESTON
Wires and Cables
Built to beat the heat

Operated by A. P. Smith Mfg. Co., East Orange, N. J.

Upkeep on this magnet averaged only $5 a year

There's good reason to examine this magnet closely. It looks like new . . . lifts like new—*but isn't new!*

This 45 inch Ohio Magnet is 22 years old. It has seen continuous service in a New Jersey scrap yard since 1925. The magnet was returned to us recently for repairs to a ground in the terminal box. Disassembly was totally unnecessary. Time out of service amounted to only a few days.

Total cost was less than $100—*less than $5 a year for 22 years.*

Naturally we'd like to claim that all Ohio Magnets give the same amazing service. Varying conditions of operation, however, make that statement impossible. *From experience we can say*: Heavier construction increases Ohio Magnet life. Extra weight is distributed throughout copper coils, insulation and steel frame—for greater lifting efficiency.

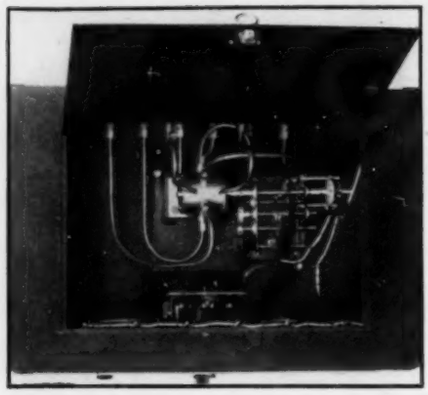
An Ohio Magnet quickly pays for itself because you move scrap directly to where you want it *in one operation—in magnet - minutes instead of man-hours.* And lower maintenance cost makes an Ohio Magnet an even sounder investment. Call on Ohio: *a leader in magnetic materials handling.*

Ohio MAGNETS

also a leading name in the small motor field

THE OHIO ELECTRIC MFG. CO.

5907 MAURICE AVE. • CLEVELAND 4, OHIO



View through top door of cabinet of atmosphere selector showing six inlet lines, purging and dew point recorder lines, connected to valve, clock timing mechanism, and rear of control panel.

primarily of a six-way valve for six incoming atmosphere sources, motor, and electric time clock; so arranged that at a pre-set time the source of atmosphere supply to the dew point recorder is automatically switched from one line to the next. In the meantime the five remaining lines which are not feeding the Recorder are continuously purged so that when the next source is to be analyzed no time is lost in purging. The source from which the atmosphere being analyzed is indicated by numbered (1 to 6) pilot lamps on the control panel of the machine.

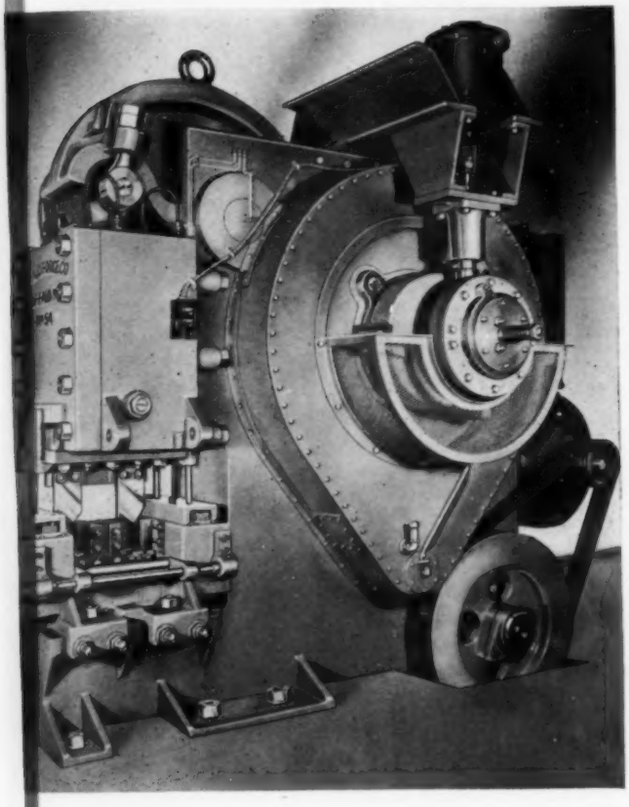
In addition to the indicating lamps, three additional controls are provided. A push button on the panel, when pressed, will manually transfer the inlet valve to the next station or source line. The frequency at which atmospheres may be analyzed for dew point is set by the large control dial in the center of the panel. An "on-off" switch is also included. A typical clock setting for the analyzing frequency is at 30 minute intervals so that six samples will be taken and recorded in a 3 hour period, with reanalyzing of each line repeated at 3 hour intervals.

Since all six lines may not be needed when the manifold is first installed, another feature of the machine provides a means of skipping one or more lines and returning the inlet valve to the initial line automatically. Thus additional capacity is available for later use without impairing the speed and initial versatility of the unit. No provision is made to cause the valve to automatically skip one individual intermediate line, as all lines in use

CLEAN, ACCURATE CUTS on the HEAVY jobs

Here's convenience and accuracy for your punching, shearing and blanking jobs up in the 250 to 1200-ton capacity range! "Buffalo" Mill Type Shears have heavy electrically-welded steel plate frames for the extreme rigidity and strength required in this work. The extra large tooling space is open on three sides. Twelve sizes. Long strokes, up to 8". The No. 54 Shear shown and described below was designed for mill service.

BUFFALO MILL TYPE SHEARS



- 420 ton capacity with 3" stroke
- 210 ton capacity with 6" stroke
- Herringbone gears enclosed in oil-tight guards
- Double-duty automatic blocking tools
- Shears channels, special rolled shapes
- Produces clean, square surfaces on both sides of cut.

Write for new Bulletin 3650 for facts on the Mill Type Shears you need.

BUFFALO FORGE COMPANY

173 MORTIMER STREET BUFFALO, NEW YORK

CANADIAN BLOWER & FORGE CO., LTD., KITCHENER, ONT.

- ★ BACK SPOT FACERS
- ★ BAR CUTTERS
- ★ BENDING ROLLS
- ★ BILLET SHEARS
- ★ DOUBLE END PUNCHES AND SHEARS
- ★ LOCOMOTIVE SHEARS
- ★ MILL TYPE SHEARS
- ★ RAPID ACTING PUNCHES
- ★ SINGLE END SHEARS
- ★ SPRUE CUTTERS
- ★ STRUCTURAL IRON WORKERS
- ★ UNIVERSAL IRON WORKERS
- ★ DRILLS FOR THE PRODUCTION LINE DRILLS FOR THE TOOL ROOM

Slowly revolving outlets distribute the heated air continuously downward in a constantly changing direction, completely and thoroughly covering the working area

Write for details

L. J. Wing Mfg. Co.

154 W. 14th Street

New York 11, N. Y.

Factories: Newark, N. J. and Montreal, Canada

can readily be connected in consecutive order. The control switch for skipping the sampling lines is located inside the unit.

The atmosphere selector is enclosed in a cabinet approximately 10½ in. high, 21 in. long, and 13½ in. deep. A door on top of the cabinet gives easy access to the interior.

AMERICAN BRAKE SHOE OPENS TWO FOUNDRIES

▲ American Brake Shoe Company's two new non-ferrous foundries recently completed at Niles, Ohio, and Meadville, Pennsylvania, were opened December 8 and 9.

The new Meadville plant, replacing an older plant of the National Bearing division formerly located there, will produce bronze bearings and castings. It will specialize in copper, brass and bronze for railroads, steel mills, and many other industries, and in precision machine bearings for diesel engines and other high-speed and heavy-duty service.

The Meadville plant consists of a main foundry building, a two-story modern office building and a separate unit housing a heating plant. Constructed of concrete and brick, the main foundry is rectangular shaped and has a total of 185,000 sq ft of floor space. It also houses a machine shop. The two-story office building is approximately 200 ft in length and contains well-equipped locker and wash rooms as well as other facilities for employees.

The new foundry at Niles, Ohio, which will manufacture railroad journal bearings, is strategically located in the heart of a three-state railway supply area which includes many car manufacturing plants.

Consisting of a foundry and machine shop, the new Niles plant is a one-story T-shaped structure having 35,000 sq ft of floor space. It is constructed of structural steel, reinforced concrete and brick.

Both new plants are equipped with the best in modern machinery and layout to insure efficient production and greatly improved products.

Besides the new plants at Niles, Ohio, and Meadville, Pennsylvania, the National Bearing division operates five other plants located in the follow-

DEAD-ENDED
without structural reinforcing
because the cable is
ALUMINUM

When you see 1,000 M.C.M. cable dead-ended to a single steel plate—without further structural reinforcing—you see one of the reasons why your over-all job costs are lower with Alcoa E.C.* Aluminum Wire and Cable. This insulated aluminum cable is less than half the weight of an identical copper cable. That's why it's easier to handle on the job, and to install.

Equally as important as this light weight are the rugged strength, durability, and conductivity of Alcoa E.C. Aluminum. That's why installations like this have been in service for as long as 30 years.

Leading manufacturers are producing insulated wires and cables with Alcoa E.C. Conductors in a wide variety of types for all plant conductor applications. Your supplier can tell you about types and sizes. Or write ALUMINUM COMPANY OF AMERICA, 2128 Gulf Bldg., Pittsburgh 19, Pennsylvania.

*E.C.: *Electrical Conductor Aluminum*

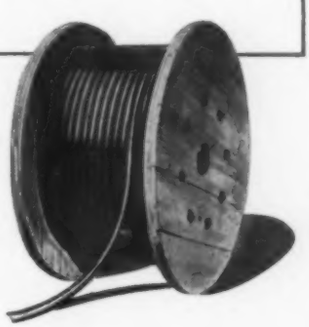
NO PROBLEMS of conductivity

NO PROBLEMS of joints and terminals

NO PROBLEMS of conduit layouts

NO PROBLEMS of availability

The BIG DIFFERENCE is in your COSTS



ALCOA EC ALUMINUM

FOR ELECTRIC WIRE AND CABLE

ing cities: Chicago, Illinois; Jersey City, New Jersey; St. Louis, Missouri; St. Paul, Minnesota; and Portsmouth, Virginia.

The Meadville and Niles plants are two of six new plants which the American Brake Shoe Company has constructed under its $15,000,000 plant modernization and expansion program.

RECIRCULATING FURNACE REVERSES GAS FLOW

▲ An entirely new and advanced type of recirculating furnace which reverses the flow of gases through the work at regular intervals has been built by Sunbeam-Stewart industrial furnace division of Sunbeam Corporation. An exclusive damper arrangement is employed to give any reversing cycle desired. This new unit has an important application in industry for the heat treatment of any high stress parts.

Work is brought up to the desired temperature faster in this new recirculating furnace than in a conventional one. This means increased tonnage. Final temperature variation through the work in a furnace of this type is negligible which, in turn, results in more uniform heat treating. In addition, where speed of heating is limited by temperature variations through the work, heating rates of the reverse-flow are greatly increased because of the small temperature variation throughout the heating cycle.

NATIONAL TUBE RELINES LORAIN BLAST FURNACE

▲ F. H. McGraw and Company, engineers and constructors, has been awarded a contract by the National Tube Company for the complete rehabilitation and relining of the No. 1 blast furnace at Lorain, Ohio. The furnace was scheduled for blow down on November 15th, with a maximum contracted down time of seventy-five days.

1947 TRENDS . . . . . STEEL

▲ In 1947 the industrial economy of the United States was strengthened by the production of more than 84,000,000 tons of steel, a tonnage greater than ever made before in a peacetime year.

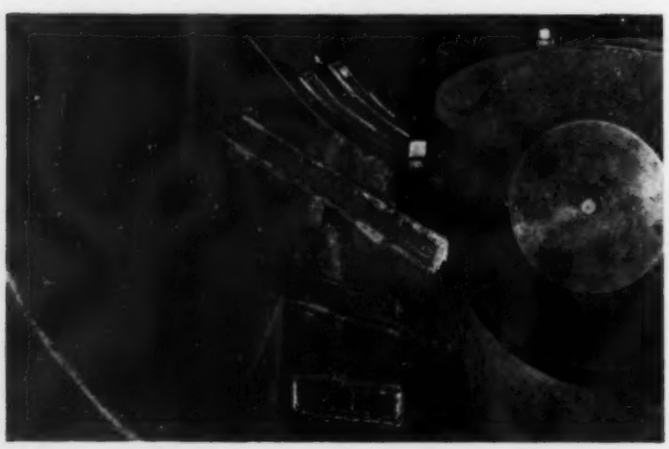
Steel production in 1948 should equal or exceed the output of 1947, assuming that existing and additional steel capacity can be operated without interruptions from work stoppages or strikes and without shortages of raw materials of the proper quality. The total of domestic and foreign demands is expected to remain heavy.

In 1948, steel companies will have the benefit of some of the new producing facilities which have been under construction for a year or more as a part of steel's one-billion-dollar expansion program, undertaken in accordance with the companies' long-

SEE PRODUCT INFORMATION
Page 135 ***IT'S NEW!***

METALOCK
Registered Trademark
A MECHANICAL REPAIR FOR WRECKED MACHINERY
THOUSANDS SAVED BY *On location* REPAIRS WITH METALOCK

STEAM ENGINE FRAME SAVED BY METALOCK AFTER WELD FAILED



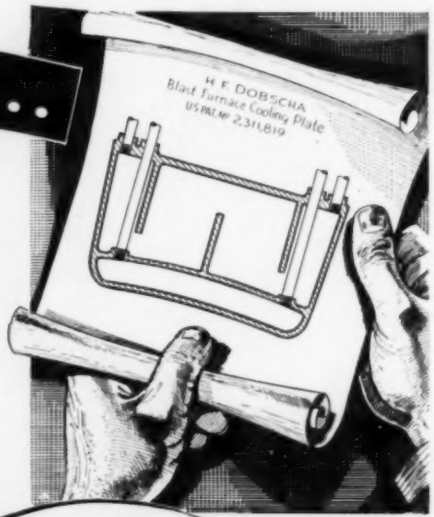
NOTE: Masterlocks used to distribute loads beyond area damaged by weld. ***Literature mailed on request***

METALOCK REPAIR SERVICE
General Office: Pennsylvania Division, 530 WILLIAM PENN PLACE
PITTSBURGH 19, PA.
HOME OFFICE: LONG ISLAND CITY 4, NEW YORK

THIS... is the DOBSCHA DOUBLE COMPARTMENT COOLING PLATE....

The Dobscha Plate is designed to allow sealing off of the "NOSE" compartment, in the event of "burning," **without reducing** the cooling area of the large volume "BUTT" compartment.

The design assures **high velocity** water travel through the "NOSE," thereby eliminating clogging due to bad water sediment.



HOW THE DOBSCHA PLATE COMES TO YOU FROM FALCON

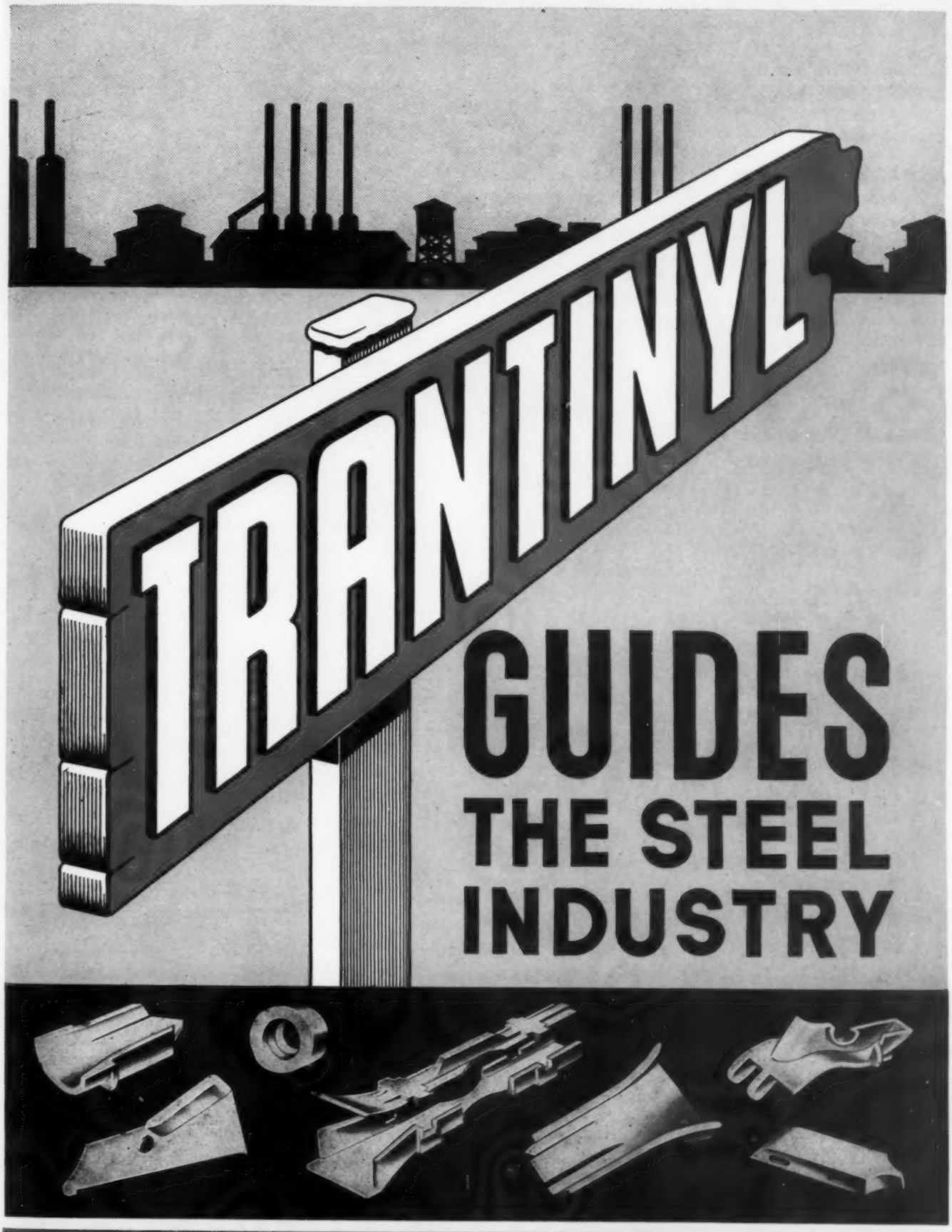
Falcon casts the Dobscha Plate vertically, without anchors or chaplets, "NOSE" down, so the densest metal is in the "NOSE" where needed.

Falcon installs the copper "Feed" and "Discharge" pipes to the nose compartment.

Falcon ships each Dobscha Plate in a special crate or cradle which protects these nose "Feed" and "Discharge" pipes in shipping and handling between the foundry and your furnace wall.

Falcon is licensed to make and sell the Dobscha Plate. U S. Pat. 2,311,819.

TELEPHONE COLLECT - 3-4355
FALCON BRONZE CO.
YOUNGSTOWN 3, OHIO
Established 1890 • Incorporated 1895



YOUNGSTOWN ALLOY CASTING CORPORATION
YOUNGSTOWN 1, OHIO

established policy of meeting whatever demand exists for their products.

The greatest possible deterrent to larger output may be insufficient quantities of good quality scrap. That problem was the major reason why the industry was unable to operate at full capacity in 1947.

It is impossible to say precisely when a balance between supply and demand for all types of steel will be reached. It must inevitably come, since the current scale of demand must be regarded as abnormal and temporary. If a balance is not actually reached in 1948, certainly the expected high production of the year will bring it close.

OHIO ELECTRIC HAS RECORD MOTOR OUTPUT

▲ Electric motor production at Ohio Electric Manufacturing Company has reached an all-time high. Daily output is now 1200 motors. Total October production, exceeded 25,000 motors. November deliveries fell below this figure due to a plant shutdown during Thanksgiving holidays.

WESTINGHOUSE ADDS TO GEAR DRIVE LINE

▲ A new vertical gear motor is the latest addition to the Westinghouse gear drive line. Each unit is a self-contained drive, consisting of a high speed motor and speed reducing unit. Nine different gear ratio combinations are available, ranging from 7.61:1 to 38.9:1.

These self-contained vertical gear motors are available in 3 to 50 hp, 220, 440 or 550 volt, 3-phase, a-c, and 3 to 7½ hp, 115 or 230 volt, d-c. They may be equipped with practically any standard motor in a variety of enclosure types including: open protected, semi or totally enclosed and explosion proof.

Special features in this new vertical gear motor are: 1. the design of the gear case is such that all gears and bearings receive positive lubrication at all operating speeds; 2. quiet operating, single helical gears and pinions of 40 to 50 carbon steel are given the exclusive Westinghouse BPT "tough-hard" heat treatment before hobbing; 3. maximum strength and tooth overlap; 4. uniform loading — slow uniform wear; and 5. lower impact stresses from sudden shocks or reversals.

DEVELOP INEXPENSIVE DEWPOINT APPARATUS

▲ To meet a growing need in a wide range of industrial and research fields for a simple, inexpensive device for measuring the moisture content of air and gases at approximately atmospheric pressure, Pittsburgh Lectrodryer Corporation is now manufacturing a dewpoint apparatus.

The company's research department points out that the results obtained with the apparatus compare satisfactorily with more complicated and expensive methods for the determination of moisture content.

They also explain that the Lectrodryer device is less likely to result in error than the wet and dry bulb method of moisture determination,

FOR A GROUP OF OIL BURNERS OF SMALL CAPACITY

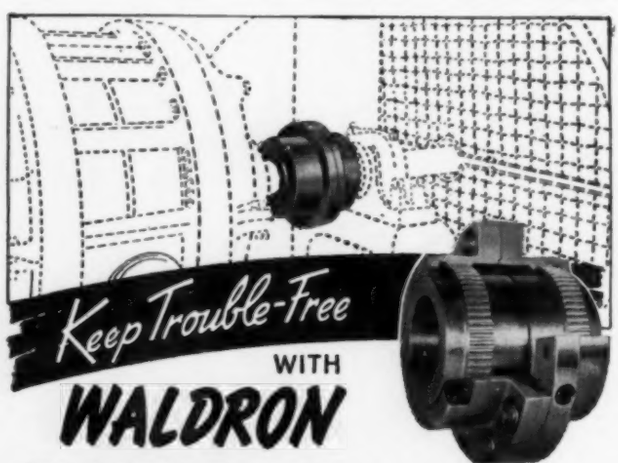
BLOOM UNIT ATOMIZER

Provides a Method of Burning Small Quantities of Heavy Fuel Oil at Each Burner

The atomizer operates on high pressure steam. It atomizes a reasonable quantity of oil and then divides and distributes this quantity into equal parts, which are delivered to a number of small burners.

An easy system to control. A workable method for a combination oil/gas application to small gas burners. Suitable for oil application to burners requiring 1½ to 3 g.p.h.

BLOOM ENGINEERING CO.
857 W. North Avenue Pittsburgh 12, Pa.



Keep Trouble-Free WITH WALDRON

ALL STEEL SERIES "A" Couplings

Permits use of larger shafting and equipment.

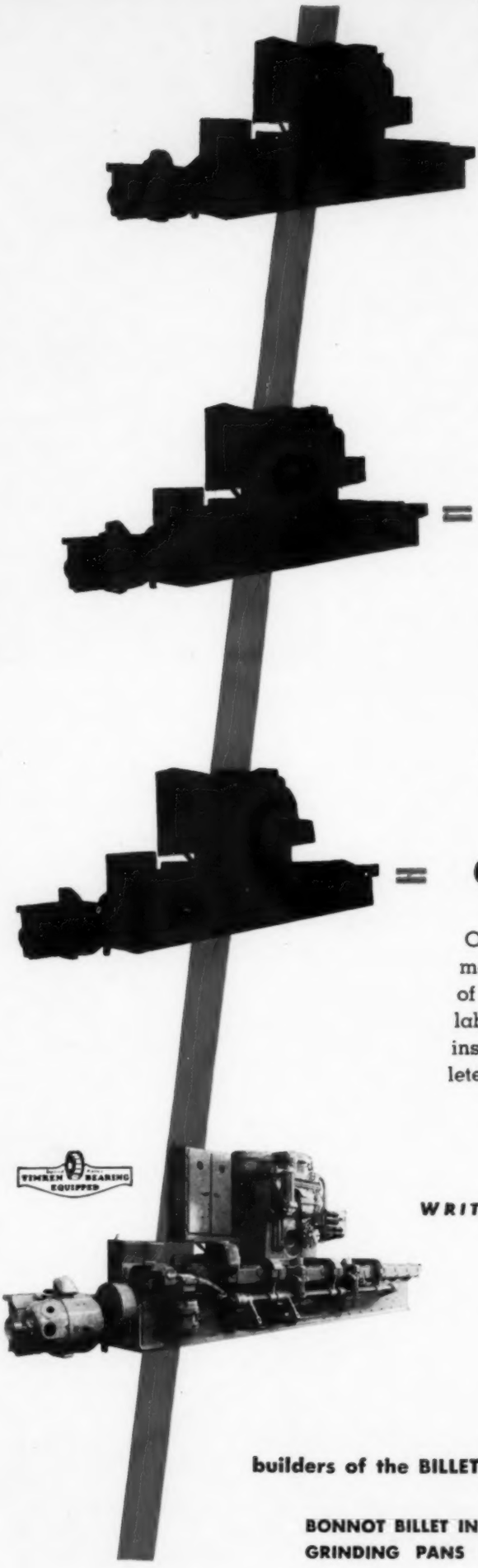
Requires less shaft extension.

Transmits no added pressure to either shaft.

Positive dust and oil proof Walflex Seal.

To avoid the common sources of trouble, WALDRON Couplings have no flexible hub connections to fatigue, such as rubber bushings, spring grids, laminated discs, etc. Accurately machined forged steel parts permit operation at high or low speeds. Full details on request.

JOHN WALDRON CORP.
Main Office and Works
New Brunswick, New Jersey
COUPLINGS



= 100% Scrap Recovery

The Billeteer saves every ounce of steel removed from billets . . . classified according to analysis . . . ready for the charging box. One mill, operating four Billeteers, saves over six tons of scrap a day . . . more than 2000 tons a year. And all this over and above the fact that the Billeteer permits salvage of billets so badly scarred that hand-chipping or flame conditioning would be impractical.

= Greater Speed

One Billeteer does the work of 10 manual chippers, and does it better. Operation of the Billeteer is simple . . . operator can be quickly trained. Designed and built for long, trouble-free service, the Billeteer keeps thoroughly cleaned billets moving rapidly and steadily from the billet shed . . . sets a more profitable pace throughout your plant.

= Greater Economy

One plant using Billeteers saved $892,528 (over manual-chipping) in conditioning 714,022 net tons of billets. By increasing billet output, cutting labor costs, increasing worker efficiency, and insuring steady, dependable operation, the Billeteer can effect impressive savings in your plant.

TIMKEN BEARING EQUIPPED

WRITE TODAY FOR FULL INFORMATION

Engineered

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To determine the dewpoint temperature a small sample of the gas to be tested is passed through the outer container while a mixture of crushed dry ice and acetone is stirred in the inner container. The stirring is done with the thermometer. As the temperature drops as a result of the stirring the polished surface of the inner compartment is closely observed through the glass window. At the first indication of dew or moisture on the polished surface of the inner container the temperature is read from the thermometer. This dewpoint temperature is a reasonable accurate indication of the moisture content of the gas or air under test.

Use of the acetone and dry ice mixture makes possible the quick checking of dewpoints as low as minus 76 C.

Users of the device are furnished complete directions to insure the best possible results.

STEEL PRODUCTION IN GREAT BRITAIN

By JOHN KINGSLEY

▲ Of Britain's October exports of £-108,000,000 ($432,000,000), no less than one-third were accounted for by two groups of manufacturers — vehicles including ships and aircraft, and machinery. The vehicle group actually headed the list, with machinery second, and iron and steel third. These facts emphasize the great importance of maintaining British steel production, which is second only to coal in priority of needs. Steel is the primary need of a great proportion of British manufacturers: without adequate supplies, a great number of the new production and export targets will be seriously upset. It is worth examining the position of this key industry.

British steel production was severely hit by the fuel and weather crises early in 1947, and, after the sorting out had been done, it looked at first glance as though there would be little hope of reaching the output target of 12,500,000 tons set out in Britain's Economic Survey (February 1947), particularly as it was only slightly below the 1946 output of 12,750,000 tons and the prewar peak of 13,250,000 tons, reached in 1939.

The target, however, was retained, although very tentatively. Excluding unforeseen adverse developments in the last few weeks of 1947, there is good reason to think that the target will be reached. To the end of October, production was 10,400,000 tons, leaving some 2,100,000 tons to produce in what, allowing for Christmas holidays, was equal to about eight working weeks. This meant 250,000 tons weekly, compared with a weekly output averaging 266,000 tons in September and 275,000 tons in October. In fact, on the latest figures, all production records are now being broken — the October output was at an annual rate of 14,316,000 tons compared with 13,200,000 tons in October, 1946.

It is well to remark here that Britain's steel plants worked an all-out job during the war, and some were badly knocked about by enemy bombing. Furthermore, all got badly into arrears with maintenance work, repairs and modernization plans. The industry since 1945 has therefore been faced with the double problem of increasing production and modernizing its plant.

Looking now to the future, the 1948 production target has been set at 14,000,000 tons. In the face of recent production figures, this appears a comparatively easy task. But though the whole British steel industry is doing a magnificent job, reaching the 1948 target will not be easy; it will in fact be a tough struggle. The worst part of the winter, with its possibilities of hold-ups in coal, transport and actual production, is imminent. Then there are the immediate and ever-present problems of raw material shortages, particularly scrap, pig iron and coke. Experts reckon that the industry will be fortunate if it can average a yearly rate of 13,500,000 tons in the first quarter of 1948, which of course means a much higher rate for the following quarters.

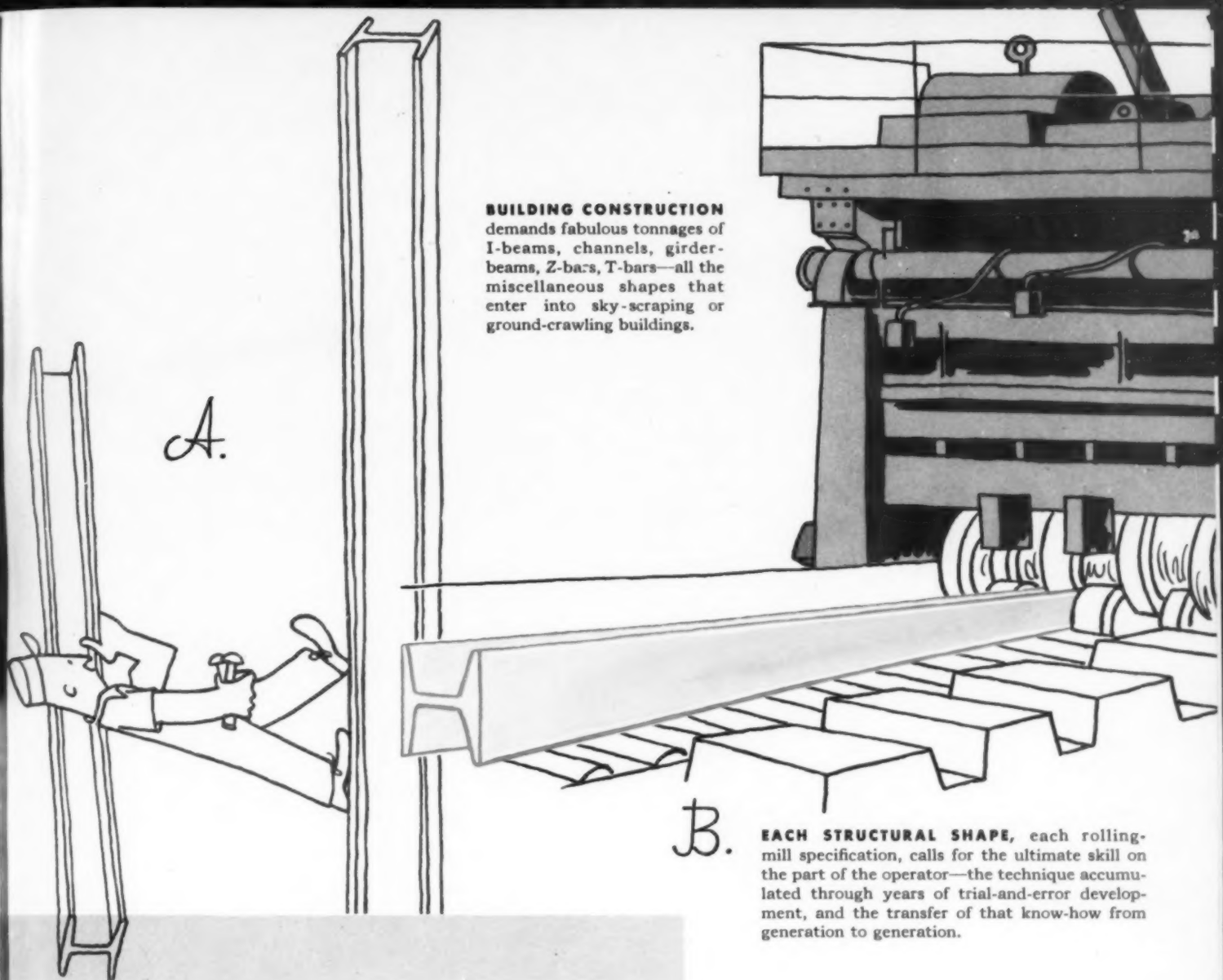
At the moment, the greatest shortage problem is scrap, supplies of which will have to be increased by some 1,500,000 tons to reach the 1948 target. Germany is now supplying about 300,000 tons of scrap a year, but Britain needs at least 1,000,000 in 1948 from that source. If the extra German scrap is not forthcoming, then Britain's 1948 steel target of 14,000,000 tons and the 16,000,000 tons which it is hoped to raise it to by 1953, is in jeopardy. This would inevitably have repercussions on other European countries and the success of the Marshall Plan, which puts such reliance on an expanding steel output.

Falling stocks of pig iron have been of more immediate concern to British steel producers. Although pig iron output was running at high weekly rate of almost 161,000 tons in October

(*Please turn to page 138*)

AIR SHEARS?

A recent application of oxygen in the steel industry involves the cutting of hot blooms and billets. The usual steel mill practice is to cut hot blooms mechanically with a shear. The cost of maintenance of the mechanical shears and the cost of the shear blades which have to be replaced very frequently, is substantial. Furthermore, the initial cost of a hot cut-off shear is in the neighborhood of $100,000. Because of these reasons, replacement of hot cut-off shears with oxygen cut-off machines appears to be quite attractive. However, the economy of the substitution is contingent upon the ability to make cuts at speeds approximating those of the shear, and research efforts, such as above in Air Reduction's apparatus research laboratory, are directed at speeding up the oxyacetylene cutting process.



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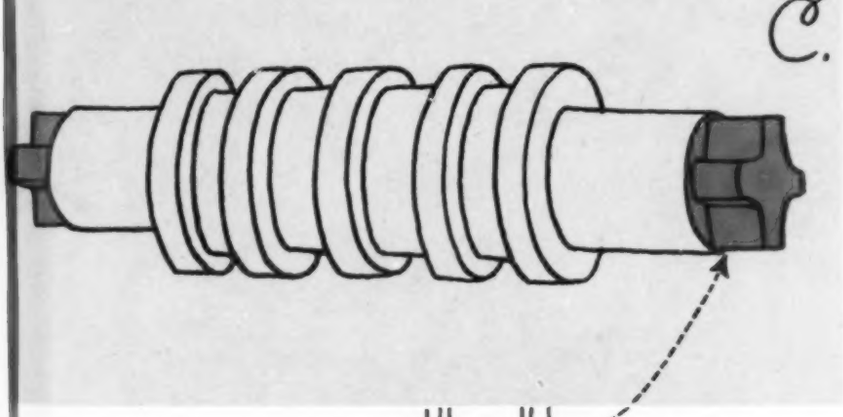

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JANUARY, 1948

(1) Induction Furnaces

Trouble-free, 20 and 40-kw spark-gap converters, used for a wide variety of induction melting, heating, brazing, and hardening applications are fully described in a new bulletin. Advantages, principles of operation, specifications, and performance data are covered. Melting furnaces from 3 to 60 lb capacity, and heating coils for use with these converters are also described. (14 A). Ajax Electrothermic Corporation.

(2) Resistance Welding

Synchro-Trol, a new line of synchronous precision, a-c resistance welding controls in a complete, unified, factory assembled package, is described in a new booklet.

Designers or manufacturers of resistance welded products select the units they need from eight basic subunits listed in the booklet: the electronic contactor, heat control and firing panel, weld timer, electronic seam weld timer, electro-mechanical seam weld timer, pulsation weld timer, and NEMA 7B and 9B sequence weld timer. Five supplementary subunits available are the voltage regulator, current regulator, forge delay timing panel, tempering sequency panel, and blank panels for mounting small control items, or permitting substitute installations. Charts show how these subunits are assembled to form various standard assemblies.

The 18-page illustrated booklet also describes the company's complete line of nonsynchronous controls, known as Weld-O-Timer, that makes available any desired combination for sequencing and timing from only four factory wired sub-assemblies and two supplementary sub-assemblies. (B-3839). Westinghouse Electric Corporation.

Copies of the booklet B-3839 may be secured.

(3) Rubber Buckets

A new four-page catalog section on its Flexite rubber pouring buckets and dippers, used for the safe and economical handling of acids, corrosives, liquid explosives and many other highly active liquids has been published by B. F. Goodrich Company. Range of applications and instructions on usage are included in the catalog section. The pouring buckets are made in flexible and semiflexible types, and the dipper of a semiflexible rubber compound. Hard rubber funnels made by the company also are described.

(4) Technical Coatings

Complete technical data on a series of high solids vinyl resins technical coatings for a variety of materials is available in a technical data folder just published. Each coating in the series is listed separately with complete information. Data sheets cover code numbers, suggested uses, type of coating, physical constants, applicable surfaces, application methods, reduction recommendations, suggest film thicknesses, drying schedules and other unclassified pertinent information. Watson-Standard Company

(5) Clean Oil

The economic value of oil purification in relation to increasing costs of finding and developing new oil fields is outlined in the current issue of "Clean Oil" which is available to you. Also included in this interesting issue is the case history of excellent maintenance benefits realized by truck operators whose truck-tractors are equipped with lubricating oil purifiers and run 100,000 to 160,000 miles between maintenance overhauls. Honan-Crane Corporation.

(6) Liquid Level Indicators

A sixteen page issue of a bulletin on "Remote Liquid Level Indicators" is available to you. Bulletin contains description of operation, outstanding features, cutaway illustrations, diagrams showing dimensions and standard arrangement. Also shown are typical installation photographs with descriptive matter showing these liquid level indicators on boiler room panels. Yarnall-Warning Company.

(7) Bronze Bearings

A new catalog on standard bronze bearings, bronze bars, and bronze electric motor bearings is just off the press. This catalog includes complete listings of new bar sizes, new standard stock sizes, new electric motor bearing sizes. In addition, it describes by text and drawings special bearings which are manufactured to customers' blueprint specifications. Also for the first time in any catalog on cast bearing bronze there is engineering information covering the installation of bearings, recommended table of press fits, instructions for grooving and for the selection of the proper type of groove, typical housing and lubrication designs for sleeve bearings and instructions for the grinding of tools to machine cast bearing bronze. The Bunting Brass and Bronze Company.

(8) Reflectogage

The operation and applications of the Sperry Reflectogage, for thickness measurement and the inspection of bond, are completely described in Technical Data Sheet 3700. Sperry Products, Inc.

(9) High Quality Gears

The units shown in a new "Power Units" bulletin are engineered to actuate linear or rotary motion. They are powered by either in-built motors, flexible cable drives or direct drives. These power units can be designed to meet your exact requirements of weight, space envelope and operational time cycle. (UPA). Foote Brothers Gear and Machine Corporation.

(10) Tank Type Cleaner

A bulletin is available describing a new

all-purpose, industrial "Tank Type" cleaner for general vacuum cleaning, dust collecting and water pick-up. Modern design, rugged construction, easy operation and power to spare are all combined in this new "Tank Type" cleaner. Air filters are enclosed. Unlike the conventional cleaner, this cleaner does not have an external bag to get in the way, instead it has a unique filtering system which is entirely self-contained. Incoming air is whirled around inside the tank and heavy particles are deposited there. The air then passes through a cloth bag filter where the dust is removed. Collected dirt is easily emptied from the cleaner by simply raising the vacuum sealed lid and then lifting out the 9 gallon tank and dust bag. (ECB-1047). Ideal Industries Inc.

(11) Refractories

A new loose-leaf catalog containing the latest data on fire brick and refractories is now ready for you. The booklet is published in seven sections, clipped together between attractive covers. Complete brick tables for all sizes of refractory brick are included in a special section as a guide to all refractory users. The tables are so constructed that brick estimates for any building relining, repairing or rebuilding job can be rapidly figured. Castable refractories, bonding mortars, fire brick, silica brick, patching mortars and acid proof cements are discussed thoroughly in the other sections. The catalog is constructed to fit neatly into brief case or filing cabinet. Robinson Clay Product Company.

(12) Controlled Heat

Just released is a new illustrated folder entitled "Controlled Heat" describing a new line of class "T" self-contained, self-acting, temperature regulators. The new folder tells how accurate temperature control can be obtained at reasonable cost for many industrial applications. Important features of this new regulator as described in this folder include single-seated construction in all sizes for steam pressures up to 125 psi; packless main valve; hard faced seating surface and hardened wearing parts; liquid filled thermostatic element — all of which are stated to assure positive control response to small temperature changes, as well as assure positive dead-end shut-off, long life and simple maintenance Leslie Company.

(13) Plant Equipment

Equipment for the metal industries is described in a new bulletin just issued. Reviewed in the bulletin are such items as high frequency converters for induction heating and melting, arc furnace transformers and control, welding machinery, heavy duty radiography equipment, and precision castings. (25B6773). Allis-Chalmers Manufacturing Company.

(14) Heliwelding

An eight page folder describing three new types of Heliweld equipment is yours for the asking. These are the manual holder the machine holder, and the electronically controlled automatic head. The new folder lists advantages and uses of the process, construction details of the equipment and a page devoted to supplementary equipment and supplies. (1632). Air Reduction Sales Company.

(15) Plate Resistors

A new bulletin describing "Tab-Weld" plate resistors, for controller and starter duty has just been published. Spot-welding of resistor-ends, off-set to bring adjacent grid-eyes into intimate contact with each other, provides a permanent current-carrying path throughout the section. Terminal-plates, closely spaced along one side of each section, are also welded in place. (942). Electric Controller and Manufacturing Company.

(16) Cutting Fluids

A completely revised edition of the booklet, "Cutting Fluids for Better Machining," a seventy-two page catalog of metal-working information, has just been published. Revised to keep pace with the latest metal cutting developments, the booklet contains a wealth of data on the application of oils for cutting, grinding, drawing, quenching and tempering, and all other phases of metalworking and industrial lubrication. In addition, useful sections on metal cutting mechanisms, selection of cutting fluids, rules for prolonging tool life, handy tables of standard steel specifications, Independent Research Committee data and marking system chart for grinding wheels are included. D. A. Stuart Oil Company.

(17) Y and Angle Valves

A new folder just released describes Durco corrosion-resisting, series 35 Y valves and series 36 angle valves and shows their internal construction by means of cutaway views. These illustrations bring out every construction detail and show, in color, exactly which parts of the valve are made of a special corrosion-defeating Durco alloy. Features are listed and a brief explanation of the type of service for which the valves are best suited, is given. The bulletin provides complete dimension data on the various sizes and includes an illustrated parts list. (615). Duriron Company, Inc.

(18) Oxygen Cutting

The availability of a new reprint entitled "Oxygen Cutting of Steel at Elevated Temperatures" written by J. F. Kiernan and J. S. Sohn has been announced. The article, which originally appeared in "The Welding Journal," concerns itself with the oxygen cutting of steels at rolling mill temperatures. Also, it contains useful data which have been derived from over 3000 controlled cutting tests. The 12-page reprint is illustrated with eight photographs and sixteen diagrams. Air Reduction Sales Company.

(19) Condensed Catalog

Release of a new bulletin which has received national recognition in a nation-wide competition for industrial sales literature is announced. Descriptions and illustrations of all Falk precision products, such as gears, speed reducers, Motoreducers, couplings, high speed drives, backstops, marine drives, special gear drives are contained within this bulletin. Available services and facilities including steel casting, machining weldments and engineering are also described. (10,000). Falk Corporation.

(20) Two Welding Bulletins

Two bulletins issued recently are now announced as special reprints to meet demands for them as reference sources by those interested in production and maintenance welding at low base metal heat. Entitled, "Arc Welding Problems Successfully Solved" one bulletin covers welding cast-iron, low and high alloy steels, stainless steel and tool steels to high carbon steels; welding special manganese parts, elimination of undesirable characteristics, and other problems occurring in everyday welding. Twelve production case histories are well presented. Illustrations of the various steps make this bulletin worth close study. The other bulletin, "Another Major Advance in Gas Welding," describes the use and applications of various new developments in the field of special flux-coated alloys. Correct welding procedures, together with physical properties, charts, and valuable technical data are well outlined and illustrated Applications discussed include steel, cast iron malleable, bronze, brass, copper. (Vol. 4, Nos. 7 and 8). Eutectic Welding Alloys Corporation.

(21) "Proof of the Pudding"

A bulletin, "Proof of the Pudding" presents a few successful installations of "Speedaire." This new worm gear speed reducer is built with a double walled housing. An induction fan, installed on the coupling end of the worm shaft, draws a high velocity air stream between the inner and outer walls of the housing, continuously removing the heat generated by the unit. As a result, the capacity of the new "Speedaire" is increased up to double the rating of standard worm gear units of equal frame size, when operated at motor speeds. This "doubling the horsepower" saves space, weight, and money. Introduced in 1944, "Speedaire" is now serving hundreds of plants in scores of industries. Cleveland Worm and Gear Company.

(22) Thermocouples and Pyrometers

A new bulletin covering thermocouples, protection tubes, and pyrometer accessories, has been published. The bulletin gives detailed drawings, complete information, and prices covering the accessories for pyrometers, which are carried in stock for immediate shipment. In addition, it contains a chart and valuable engineering data on selecting the right thermocouple and protection tube. (P1235). Bristol Company.

(23) Homocarb

To describe for the first time how numerous "Homocarb" furnaces are now being used for gas cyaniding, and to provide up-to-date information about the latest improved equipment for carburizing steel, a revised 25-page illustrated catalog, "Homocarb Method for Carburizing and Gas Cyaniding," has been released. In this new publication there are installation photographs of "Homocarb" furnaces which, equipped with a simple assembly, are enabling users not only to obtain precision

carburizing at low cost, but to use the furnace equipment for precision gas cyaniding . . . a process which rapidly produces a file-hard surface on parts which require a relatively shallow case. Also described and illustrated is the improved "Homocarb" control panel complete with "Micromax" electric control, time clock, accessories and its related contactor cabinet. A diagrammatic view of the "Homocarb," with built-in natural-convection cooler, shows how the load is protected not only during heating and soaking, but during cooling as well. A large chart shows the uniformity obtained when temperature, quality of gas, amount of gas and time are under precise control. Illustrations demonstrate how easy the equipment is to operate. (T-623). Leeds and Northrup Company.

(24) Tool and Carbide Parts

A completely new 65-page general tool and carbide parts catalog, showing standard cemented carbide products, with specifications and prices, has been issued. Among the new products shown in the new catalog are a new standard line of solid boring bars as well as an expanded line of solid boring tools. These solid carbide boring bars, due to their high degree of rigidity, are designed for precision boring of holes having a length up to 8 times hole diameter. The bars are available in two types. The first type — using a carbide boring tool brazed into a recess in one end of the bar — is available in only one size. The second type — having a steel insert in which the carbide boring tool is held and adjusted with set screws — is standard in a range of 7 sizes. (GT-200). Carboloy Company, Inc.

(25) Bearing Catalog

Available is a 260-page ball bearing catalog "K," containing 100 pages of engineering information and data. The first section describes and illustrates all of the many types of anti-friction bearings produced by Federal and contains interchangeability and conversion tables. The engineering data section contains detailed information on calculation of loads, various bearing load conditions, a load modifying chart, lubrication and care of bearings, and various formulas, tables and equivalents of help to the engineer. (K). Federal Bearings Company, Inc.

(26) Steel Mill Equipment

Publication of a new 16-page catalog is announced, describing and illustrating charging equipment and varied other devices for the iron and steel industry. Included in the new catalog are details on auto floor charging machines, auto floor manipulators, overhead chargers, goggle valves, electric mechanical clay gun, electro hydraulic clay gun, dry slag granulating mill, soaking pit cover carriage and various types of grab, hydraulic, slag and dump buckets. Edgar E. Brosius Company.

(27) Platform Scale

A 16-page bulletin on the new "Load King" dormant platform scale, has been prepared. The radically new platform scale, described and illustrated in the catalog, was designed to eliminate excessive wear on the main pivots due to such causes as dropping heavy loads on the scale from overhead cranes and hoists, and from lateral movement of the scale platform caused by driving trucks onto the platform. The main pivots are protected by a new outboard, corner support bearing construction. By means of corner load links and auxiliary fulcrum pivots, shock loads and lateral platform movement are prevented from damaging the main fulcrum pivots. Seven cut-away illustrations explain the working of the new mechanism. By means of the new construction, scale accuracy is prolonged, excessive wear on pivots is eliminated, and scale life is increased. Four charts give scale dimensions, platform sizes, scale capacities, dial graduations, tare beam capacities, beam capacities and shipping weight, for both self-contained and semi-self-contained dormant platform scales. (P714C). Yale and Towne Manufacturing Company.

(28) Plating Barrels

A new catalog is available covering a wide range of plating barrels, from the small single-unit apparatus to the large multiple-unit production installation. Special points of interest are new developments including a pumping apparatus for circulating the solution, the new "Merlon" cylinders for resistance to a variety of solutions and the new sizes of barrels, with dimensions given for inside measurements as well as styles having outside measurements. Other features include all types of contacts, triple tie rod hanger, tanks, motor drive, portable and horizontal barrel units, multiple cleaning, plating and rinsing equipment, hoists, hopper units, loading and transfer stands, exhaust arrangements, oblique barrels (single and multiple cylinder units), variable speeds, etc. (PB-107). Hanson-Van Winkle-Munning Company.

(29) Electrical Welding

A new 12-page catalog fully describes a complete line of welding electrode holders, ground clamps, cable connectors, machine terminals, cable splicers, lugs and carbon holders. Quantity price and parts information is included. Bulletin shows new models. (1948T). Tweco Products Company.

(30) Crushers

A publication is available describing jaw crushers, gyratory-crushers, gyrasphere crushers, and double roll crushers. A complete line of crushers is covered in this bulletin with illustrations, cutaway views, diagrams, dimensions, specifications, and other technical data. If you have a crushing problem in your plant, we recommend that you send for this bulletin. (271). Smith Engineering Works.

(31) Reels

A complete catalog on reels for air hose and electric cables is available. The reel application you need depends upon the type of reeling service required. This catalogue will tell you details on types of reels available and types required. These reels are of steel construction, fabricated and welded from standard shapes. This construction permits great flexibility of design. Springs, gearing, two-way pay-out, and special reels also are described in this bulletin. (345). J. L. Gleason and Company, Inc.

(32) Hot Blast Mixer

Literature is available on a highly efficient air mixing system that has been developed, making possible a uniform temperature of hot blast entering the various tuyeres around a blast furnace. This mixing system is very simple in construction and has been installed in a number of blast furnaces. The mixer consists of a simple brick Venturi tube built in the brick lining of the hot blast main near the bustle pipe. There are no moving parts employed, no special mains, valves, or other pipe required. No changes to the existing steel work are necessary. S. P. Kinney Engineers, Inc.

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(33) Electric Products

A quick reference listing of electric products is available to you covering: safety switches, double throw switches, service entrance and meter service switches, meter socket, multibreakers, lighting panel ports, distribution panel ports, bus ducts and feeder ducts, industrial control, industrial circuit breakes. Application data and a complete index is available. (May, 1947 — 107). Federal Electric Products Company.

(34) Ballbearings

A catalog is available on super-precision ballbearings built to ABEC 7 tolerances with special emphasis on their use in spindles, work heads, boring heads, live centers and the like. Such bearings are described as the means where high speed or very accurate precision must be done with superior efficiency and where long life with infrequent replacement is essential. The catalog carries general information on mounting, pre-loading, lubricating, etc., with dimensions and low ratings of the various sizes manufactured. In addition, there are detailed drawings of actual examples. (Super-precision). Fafnir Bearing Company.

(35) Rotary Pumps

A new bulletin on "Steam Flow Rotex" pumps is available. These are rotary type, positive displacement pumps used for moderate or low viscosity liquids of medium pressure. The pumps are constructed in either gear-in-hand or external gear-in-bearings. They can be used for pumping, lubricating, non-lubricating, and viscous liquids such as acids, alcohol, alkalis, asphalts, cellulose, coolants, lubricants, fuel oils, and numerous other liquids. The folder contains complete specifications, dimensions, and performance charts. Quimby Pump division, H. K. Porter Company, Inc

(36) Steam Cleaner

A new utility motor, "Hypressure Jenny," steam cleaner has just been announced in new literature available to you. This cleaner is said to be a full powered, extra heavy duty, all-purpose steam cleaner. The new unit features instant starting (ready to clean in less than a minute); also featured are simplicity of design and operation, rocket welded unit construction, complete accessibility of all work parts, continuous electric spark ignition, and pressure atomizing oil burning. Homestead Valve Manufacturing Company.

(37) Refractory Skid Rails

A booklet is available describing skid rails made of "Carbofrax," silicone carbide refractories now used in a wide variety of furnaces. Dry skids of this refractory are utilized to replace water-cooled pipes, thereby eliminating the cool spots with water cooling. They are also used for replacement of special heat resisting, uncooled, alloy skids. The life of this new rail is usually several times longer than obtained from uncooled alloy rails. Normally, these rail installations have a lower cost than either of the conventional skid constructions. This factor, coupled with a longer life and reduced maintenance expense makes their use definitely economical. For specific examples of their utility, we refer you to this catalog. (5110). Refractory division, Carborundum Company.

(38) Pylets

A catalog is available summarizing complete data on conduit fittings, plugs, and receptacles, flood lights, turbogenerators, and head lights. Included in this catalog are illustrations, specifications, dimensions and prices. Where necessary descriptions are included. All electrical department men should have this catalog in their files. (44). Pyle-National Company.

(39) Ammonia

"Unloading and Storage of Anahydrous Ammonia in Tank Car Quantities" is the title of a technical bulletin which is available to you. The information contained in this bulletin will be of extreme value to all persons handling ammonia in large quantities. Illustrations, diagrams, and tables contain data you will need. (a-6102). Ammonia Department. E. I. du Pont de Nemours and Company, Inc.

(40) Testing and Measuring

A specialized testing and measuring catalog has just been published giving information on more than ninety modern equipments. Some of the equipments were developed for General Electric's home factories and laboratories. Other equipment was developed at the request of other companies' factories and laboratories and since then have been made available throughout the industry. Products in this catalog are grouped under functional or "use" headings, simplifying the finding of specific products of interest. All engineers interested in testing and measurement should have this catalog in their file. (GEA-639). General Electric Company.

(41) Hot Metal

A folder is available describing Pollock hot metal cars and ladles. Diagrams, illustrations and technical data are included, as well as tabulations showing capacities, movement of cars and ladles at each installation with date of installation. (5747). William B. Pollock Company.

(42) Wire Ahead . . .

. . . a manual of electric system planning and maintenance to assure continuous operation is yours for the asking. This publication is designed to show you whether your electric system is an asset or a liability from the standpoint of continuous plant operation. It is designed to help you investigate inadequate wiring and overburdened electrical equipment. It tells you how this menace can remain unseen until a major breakdown occurs. The manual is directed to the electrical department personnel as a guide to effective elimination of inadequate wiring conditions. (C-64). Anaconda Wire and Cable Company.

(43) Texrope Drive

A new 144-page, indexed catalog for pre-engineered stock Texrope drives which simplifies drive selection so persons untrained in V-belt engineering can readily specify proper drives, is yours for the asking. In the process of development by Allis-Chalmers Texrope engineers for more than a year, the catalog is said to represent one of the most outstanding compilations of engineering data ever assembled for the industry. Nearly two-thirds of the new book is devoted exclusively to pre-engineered stock Texrope drives. (20B6956). Allis-Chalmers Manufacturing Company.

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COMPANY _____

CO. ADDRESS _____

CITY _____ ZONE _____ STATE _____

PRODUCT *Information*

ON ANY OF THE PRODUCTS MENTIONED IN THIS ISSUE

Below is an index of products referred to in editorial and advertising pages of this issue. If you desire additional information on any of them, use one of the accompanying postcards in requesting it. In each case give name of product and page number. The information will come to you directly from the manufacturer involved.

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IRON AND STEEL ENGINEER — January, 1948

Please send me additional products information as requested below:

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" " " " .....

Name.....

Title or Position.....

Company.....

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BUSINESS REPLY CARD

First Class Permit No. 1963, Sec. 510 P.L.&R. Pittsburgh, Pa.

IRON AND STEEL ENGINEER

1010 EMPIRE BUILDING

PITTSBURGH 22, PA.

THE ENGINEERING MART

WHERE TO BUY
EQUIPMENT FOR SALE
POSITIONS VACANT
POSITIONS WANTED

AN *IRON and STEEL ENGINEER* SERVICE TO THE STEEL MILL OPERATORS

WHERE TO BUY

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PAUL W. WENDT & SONS
Manhattan Building
CHICAGO 5, ILLINOIS
District Representatives for
A. W. CADMAN MFG. CO.
HUNTER SAW & MACHINE CO.
GRAFO COLLOIDS CO.

CLEVELAND DISTRICT

HARRY J. FISHER AND ASSOCIATES
635 Ferguson Building
CLEVELAND 14, OHIO
Phone: MAin 0810
Representing:
Clark Controller Company
Lapp Insulator Company, Inc.
Pennsylvania Transformer Company
Branch Offices in Youngstown and Akron

DETROIT DISTRICT

LOYAL R. MILBURN
Consulting Electrical Engineer
Registered
State of Michigan
—
Fellow, AIEE
B.S. in E.E.
Past President, AISE
—
16929 Lawton Avenue
Detroit 21, Michigan
Telephone: University 13874

PITTSBURGH

PATTERSON-EMERSON-COMSTOCK, INC.
ENGINEERS AND CONSTRUCTORS
Specializing in Steel Mill Construction
313 E. Carson Street
Pittsburgh 19, Pa.
Phone EVerglade 9800

W. G. KERR CO.
520 Oliver Building PITTSBURGH, PA.
Foote Brothers — Gears and Speed Reducers
Reeves Variable Speed Drives
Thomas Flexible Couplings
Telsmith Crushers
Phone: ATlantic 4254

ROLLING MILLS and EQUIPMENT
FRANK B. FOSTER, INC.
2217 OLIVER BUILDING PITTSBURGH 22, PA
Cable Address "FOSTER" Pittsburgh

EDGAR M. MOORE & CO.
502 Renshaw Building
PITTSBURGH 22, PA.
Transformers – Timers – Cable Take-up Reels
Resistors and Rheostats – Selenium Rectifiers
Pumpless Blow Torches

DISPLAY CLASSIFIED ADVERTISING RATES

All displayed classified advertising is sold in multiples of one inch at the flat rate of $8.00 per column inch. Minimum insertion is one inch. Maximum insertion is one column, 10 inches deep, or two columns, 5 inches deep.

UNDISPLAYED CLASSIFIED ADVERTISING RATES

All undisplayed classified advertising is sold at the rate of $1.00 per line. Five line minimum insertion charge. A box number address counts as one line.

Deadline:

All copy must be received by the 20th of the month preceding publication date.

IRON AND STEEL ENGINEER
1010 EMPIRE BUILDING
PITTSBURGH 22, PA.

PITTSBURGH (Continued)

METALLIC RECUPERATORS
(Air Preheaters)
For application to soaking pits, heating, and other types of metallurgical furnaces.
HAZEN ENGINEERING CO.
Park Building PITTSBURGH, PA.

ROBERT T. JOHNSON
District Sales Representative
NORTHERN ENGINEERING WORKS
E.O.T. Cranes – Electric Hoists – Air Hoists
THE HILL-ACME CO.
Alligator Shears – Portable Cranes – Special Machinery
Union Trust Building
PITTSBURGH, PA.
Phone: ATlantic 1535

PENNELL ASSOCIATES
Complete Material Handling Systems
O. R. Heidenrich
Investment Building
PITTSBURGH 22, PA.
ATlantic 6734
ELWELL-PARKER ELECTRIC CO.
Electric Industrial Trucks
NUTTING TRUCK AND CASTER CO.
Warehouse and Floor Trucks
PHILLIPS MINE AND MILL SUPPLY CO.
Heavy Duty Trailers, Skids, Transfer Cars, Skid Dumps
WHITING CORPORATION
Electric Hoists
LIFT TRUCKS, INC.
Hand and Power Driven Lift Trucks
ELIZABETH IRON WORKS
Bridge Ramps for Car Loading
THE BUDA COMPANY
Buda Chore Boy

WHY NOT TAKE ADVANTAGE OF THESE DISTRICT LISTINGS? MANY POTENTIAL CUSTOMERS MAY WANT YOUR PRODUCT OR SERVICE, BUT MAY NOT KNOW WHERE YOU ARE LOCATED.

THE ENGINEERING MART

PRODUCTS

Acid-Proof Materials

Specify SAUEREISEN
ACIDPROOF CEMENTS—COMPOUNDS
FOR
Tanks, Sewers, Stacks, Floors
Technical cements for all purposes.
Send sketches or samples
Sauereisen Cements Company · Pittsburgh 15, Penna.

BUSINESS OPPORTUNITIES

LINES WANTED!

Manufacturers' Agent wants to add electrical lines in Pittsburgh and Youngstown District. Fourteen years industrial sales experience with wide acquaintance in steel industry. Address Box 100, IRON AND STEEL ENGINEER, 1010 Empire Building, Pittsburgh 22, Pennsylvania.

LINES WANTED

Manufacturers' representative in the Pittsburgh district wants additional accounts. Mechanical products and supplies for the steel industry preferred. Fifteen years industrial sales experience in Pittsburgh. Address Box 101, IRON AND STEEL ENGINEER, 1010 Empire Building. Pittsburgh 22, Pennsylvania.

POSITIONS VACANT

ELECTRICAL ENGINEER, experienced in design, operation, and maintenance of steel mill machinery. Work in England and Europe for large American manufacturer. Address Box 102, IRON AND STEEL ENGINEER, 1010 Empire Building, Pittsburgh 22, Pennsylvania.

STRUCTURAL DESIGNER WANTED

Experienced in coal and ore bridges, dock cranes and material-handling equipment. Must be capable of preparing stress sheets and layout work for detailers. Permanent connection. Give qualifications, experience, and salary expected. Address, A. J. Lichtinger, care of Wellman Engineering Company, Cleveland 4, Ohio.

NEWS SUPPLEMENT

(*Continued from page 128*)

there is no guarantee that this rate can be maintained. Coke also is in short supply, although, as with pig iron, the government is giving every priority to the maintenance of adequate production.

So much for the unfavorable factors. On the credit side, the British steel industry has no labor problems, nor has it had any of major importance for many years. This is entirely due to the good relationships which exist between workers and managements, and to the good wages paid. Excellent negotiating machinery, whereby every worker has direct access to his management through his elected trade union representative, has done more than anything else to build up harmonious working. At present, steel men work a 48-hour week, which is above the average for British industry generally. Incentive schemes are operating in about 85 per cent of the industry. Results are evident in the production figures which, incidentally, are now showing something like a 10 per cent increase in output per man. Another credit item is the big modernization scheme now going ahead throughout the industry. Plans already sanctioned total more than £-100,000,000 ($400,000,000). All have top priority and several are scheduled to be completed in the next few years. In addition to increasing production, these new projects will help to cheapen costs and speed up output.

Until supplies and stocks of pig iron, scrap and coke are built up very substantially, Britain cannot afford to be complacent about steel. But such caution for the future need in no way detract from the magnificent production figures achieved by the workers in this industry.

UNITED EXPANDS AT VANDERGRIFT PLANT

▲ Increased facilities for the manufacture of rolling mill equipment to help meet the unprecedented demand for strip steel and other rolled products, have just been completed at the Vandergrift, Pennsylvania, plant of United Engineering and Foundry Company, Pittsburgh, Pennsylvania. Roll making facilities have been expanded, floor space increased, and additional modern equipment installed. Further improvements are contemplated and will be made as rapidly as equipment can be obtained. Vandergrift is one of six United Engineering and Foundry Company plants manufacturing rolling mills and mill equipment for the steel industry.

METAL SPRAY GUN FOR METALLIZING

▲ Metallizing Company of America has announced the development of a completely new type metallizing gun powered by an electric motor. This new unit is called the "Mogulectric" metal spray gun.

The new spray gun can be used in production line spraying or other types of spraying where top speeds are essential and service is a must. By using different combinations of gearing most any spraying speeds can be obtained so as to spray at top efficiency any of the metals used. Through the use of an electric drive, air requirements are materially reduced and turbine adjustments are eliminated.

The unit is powered with a 1/20 hp constant speed induction motor, thereby assuring a uniform wire speed and eliminating nozzle damage due to incorrect turbine adjustment. The wire will not feed too fast nor will it feed too slow and the only adjustments required are gas and air.

At the front end of the motor is the gear reduction which runs in a bath of fluid grease enclosed in an aluminum housing. The gears are of ample proportions to assure long life and all shafts are mounted in oversize ball bearings with ratings far above any loads imposed.

The drive component carrying the feed rolls and combustion unit can be swung around from a horizontal spraying position so the gun can spray vertically, up or down or at any angle if desired. The feed rolls can be removed for cleaning if necessary. No special tools are required.

According to the manufacturer this type of metal spraying is extremely simple. The only adjustments are gases and air. To put the gun in operation it is only necessary to turn on the switch and light the gun. No guess-work as to wire feed. Like its predecessors, it is designed to give a concentrated spray and leave a dense coating of fine texture.

19 MORGAN STRIP and SKELP MILLS are promoting recovery in five countries

In the United States, England, France, Belgium and Germany Morgan mills are on the job turning out great quantities of strip and skelp at low cost . . . helping people to help themselves.

However these mills were bought for only one purpose: **To make a profit.**

Morgan mills have consistently demonstrated their value in good times and bad . . . in seller's market or buyer's market . . . whether labor and materials are scarce or plentiful.

If profit is your motive—and we all must profit—let us talk with you about your next mill.

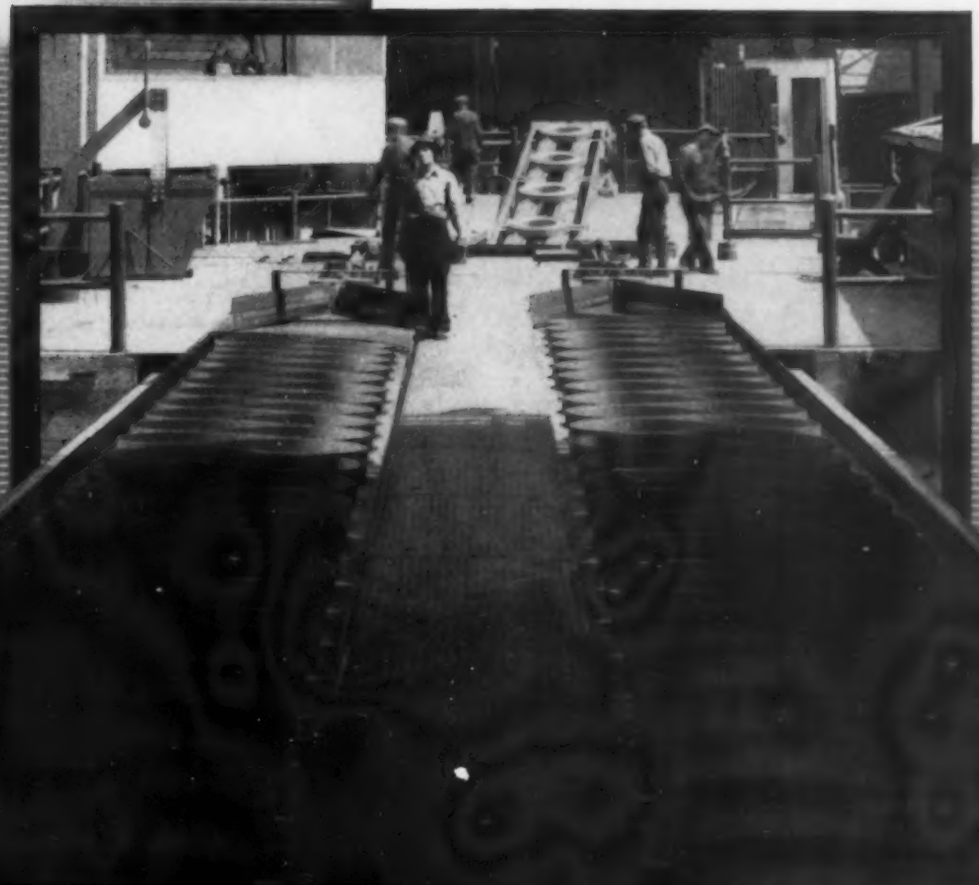
MORGAN CONSTRUCTION CO.

WORCESTER, MASSACHUSETTS

Rolling Mills - Morgoil Bearings - Wire Mills
Regenerative Furnace Control - Air Ejectors

English Representative:
International Construction Co., 56 Kingsway, London, W. C. 2, England

RM-74



Personnel News . . . .

R. B. Gerhardt has retired as chief engineer of construction of Bethlehem Steel Company. Mr. Gerhardt started as an electrician apprentice in 1899 at the Steelton plant of Pennsylvania Steel Company, which was later acquired by Bethlehem Steel Company. In 1903 he was granted leave of absence to attend Cornell University, where he was graduated in 1907 with a degree in mechanical engineering. Upon graduation he worked as electrical and mechanical engineer at Cuban Mine Development of Spanish American Iron Company, a subsidiary of Pennsylvania Steel Company.

In 1913 he was transferred to the Sparrows Point plant as electrical superintendent and in 1923 he became assistant general manager. He served in this capacity until 1927 when he was appointed assistant general manager of the Steelton plant. In 1937 he came to Bethlehem as assistant chief engineer of construction, and in 1938 became chief engineer of construction.

L. J. Gould succeeds R. B. Gerhardt, retired, as chief engineer of construction, Bethlehem Steel Company, Bethlehem, Pennsylvania. Mr. Gould was born at Sparrows Point, Maryland. He attended Johns Hopkins University, graduating in 1924 with a degree in engineering, and was employed by Bethlehem the same year. After completing the company's loop course he was made engineer in the mechanical department at the Sparrows Point plant and in 1928 he became assistant superintendent of the department. In 1939 he was transferred to Bethlehem, as assistant chief engineer of construction. From August, 1940, to October, 1944, he served with Bethlehem's shipbuilding division, as construction engineer.

A. J. Fisher, 1948 president of the Association of Iron and Steel Engineers, has been appointed assistant chief engineer of Bethlehem Steel Company, Bethlehem, Pennsylvania. Mr. Fisher graduated from the University of Colorado, college of engineering in 1924, with a degree in mechanical engineering. He was employed by Bethlehem the same year, and after completing the loop course, he was made assistant master mechanic in the sheet and tin mill division at the Sparrows Point plant. After serving in several capacities in various departments at that plant he became fuel engineer in 1929, a position he has held up to the present time.

R. Conrad Cooper was made vice president, industrial engineering of United States Steel Corporation. Mr. Cooper, who has been assistant vice president, industrial relations since 1945, assumed this newly created position on January 1, 1948.

A native of Beaver Dam, Kentucky, Mr. Cooper, after attending public schools in South Dakota, graduated with a civil engineering degree from the University of Minnesota in 1926.

After holding various positions in the field of industrial engineering, Mr. Cooper joined the Wheeling Steel Corporation in 1937 on the staff of the vice president in charge of operations, and served as assistant vice president from 1940 to 1945.

During World War II Mr. Cooper served as industry member of the National War Labor Board Steel Commission, and with the War Manpower Commission as management member of the Management-Labor Policy Committee.

L. R. Milburn has established a consulting engineering firm at 16929 Lawton Avenue, Detroit 21, Michigan. Mr. Milburn was formerly electrical engineer with Great Lakes Steel Corporation. He was born in Patoka, Indiana, and was graduated from the University of Michigan with a bachelor of science degree in electrical engineering in June, 1918. He served in the United States Army during World War I and remained active in army reserve work, attaining the rank of major. After early experience with General Electric Company, Mr. Milburn moved to the Louisville Gas and Electric Company and in 1929 went to Great Lakes Steel Corporation as an electrical draftsman. He remained in this position until 1933 when he was appointed acting electrical engineer. In 1935 he was promoted to electrical engineer, the position he held until leaving Great Lakes Steel Corporation.

Mr. Milburn has just completed his 1947 term as president of the Association of Iron and Steel Engineers. He is a registered engineer in the state of Michigan, and a fellow in the American Institute of Electrical Engineers.

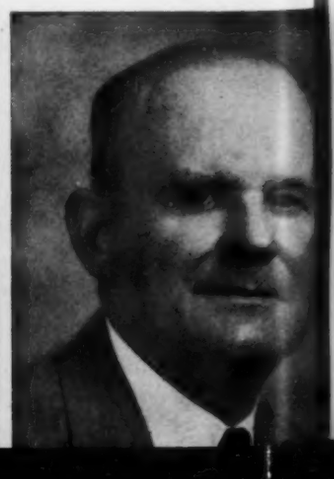
M. W. Reed has been appointed chief engineer, United States Steel Corporation of Delaware. Mr. Reed,

R. B. GERHARDT

L. J. GOULD

A. J. FISHER

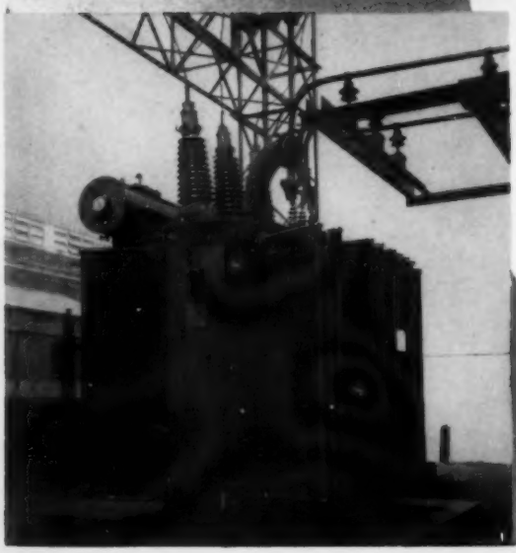
L. R. MILBURN



5 Pennsylvania Transformers--126,667 KVA

Pennsylvania TRANSFORMERS

PENNSYLVANIA Transformer Company supplied 5 Power Transformers to Carnegie-Illinois Steel Corporation in the Pittsburgh district at Homestead and Duquesne. Totaling 126,667 Kva, these giant transformers are complete with Pennsylvania's Precompressed Coils, Detachable Uni-Row Radiators and Straight-Line Tap Changers with Silver-Alloy contacts. The fine, rugged construction found in all Pennsylvania Power Transformers is exemplified in these transformers.



In Operation at the Homestead Works

Two 20,000 Kva, OISC, 26,667 OIFAC, 3 Phase, 25 Cycles, 55°C, 44,000 — 6600 volts.

These transformers supply power to:

1. The 100" Semi-continuous Plate Mill
2. The 160" Plate Mill
3. The 45" Slabbing Mill
4. The No. 5 Open Hearth Shop
5. New Armor Plate Department
6. Auxiliary Equipment for the foregoing.

In Operation at the Duquesne Works

Two 25,000 Kva, OISC, 33,333 OIFAC, 3 Phase, 60 Cycles, 55°C, 69,000 — 22,000 volts.

These transformers supply power to:

1. One 70-Ton Electric Furnace
2. Two 35-Ton Electric Furnaces
3. Auxiliary Equipment.

One 5,000 Kva, 6667 Kva with additional radiators, OISC, 3 Phase, 60 Cycles, 55°C, 69,000/23,000 — 6600 volts.

This transformer supplies power to:

1. Four 500 Kw Mercury Arc Rectifiers
2. The Alloy Heat Treating Department
3. Auxiliary equipment for the project.

Pennsylvania
TRANSFORMER COMPANY
808 RIDGE AVENUE • PITTSBURGH 12, PENNSYLVANIA

Lintern

AIRE-RECTIFIER

Installed on Coke Quench Car

This is the first of a series of 16 installations of Lintern Aire-Rectifiers purchased by one of the country's largest steel companies for use on quench cars, larry cars, coke pushers and door cranes.

It is the first installation of its kind anywhere. The fully enclosed cab replaces the old open cab with its hazards of steam, gas, and hot coke . . . results in safety for men and equipment, and assures better and greater production.

The Aire-Rectifier provides normal temperature in the cab of 80° to 85°, protecting the operator against the high temperatures (running up to 130°), and providing clean, healthful air with the coke dust, steam and SO_2 filtered out.

These Aire-Rectifiers are the only ones specifically engineered for all steel mill and foundry applications, and which cover all requirements with standard models. They are the only make universally used the country over, in all types of industrial applications, the result of long specialization in hot metal cab conditioning.

Write for Bulletin AC-111546.

THE LINTERN CORPORATION

54 LINCOLN AVENUE BEREA, OHIO

Glowlite Signals, Lanterns, Markers, Shock Absorbers for Lamps, Ventilating Heaters, Aire-Rectifiers for Overhead Cranes

who has served with subsidiaries of United States Steel Corporation continuously since 1916, has been vice president, engineering, Carnegie-Illinois Steel Corporation, since April of this year.

A native of Lexington, Massachusetts, Mr. Reed

M. W. REED

attended public schools in that area and was appointed to the U. S. Naval Academy from which he graduated with a bachelor of science degree in 1916. He was employed in October of that year at the North works of American Steel and Wire Company in Worcester, Massachusetts as a wire rope tester. He progressed through various positions at both the North and South works in Worcester, and at the New Haven plant of the same company, to the position of superintendent of New Haven works which he held from 1925 to 1928.

He became assistant district manager of the Worcester district in 1928 and in 1932 was promoted to chief engineer, American Steel and Wire Company, with headquarters in Cleveland. He became vice president of American Steel and Wire in 1937 and served in that capacity until his appointment as chief engineer of Carnegie-Illinois in 1939.

C. H. Williams has been appointed chief engineer, Carnegie-Illinois Steel Corporation, Pittsburgh, Pennsylvania. Mr. Williams was graduated from the Uni-

C. H. WILLIAMS

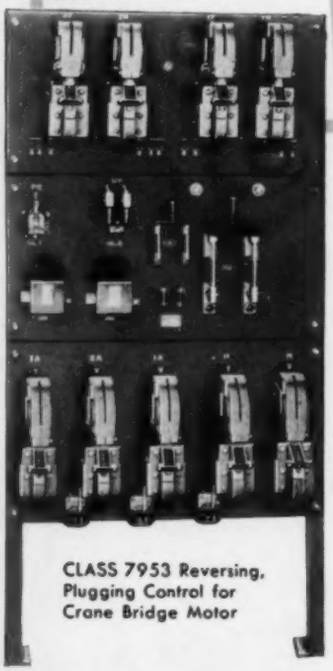
versity of Colorado in 1926 and was employed by Jones and Laughlin Steel Corporation as shear fore-

New Mill-Type MASTER SWITCH

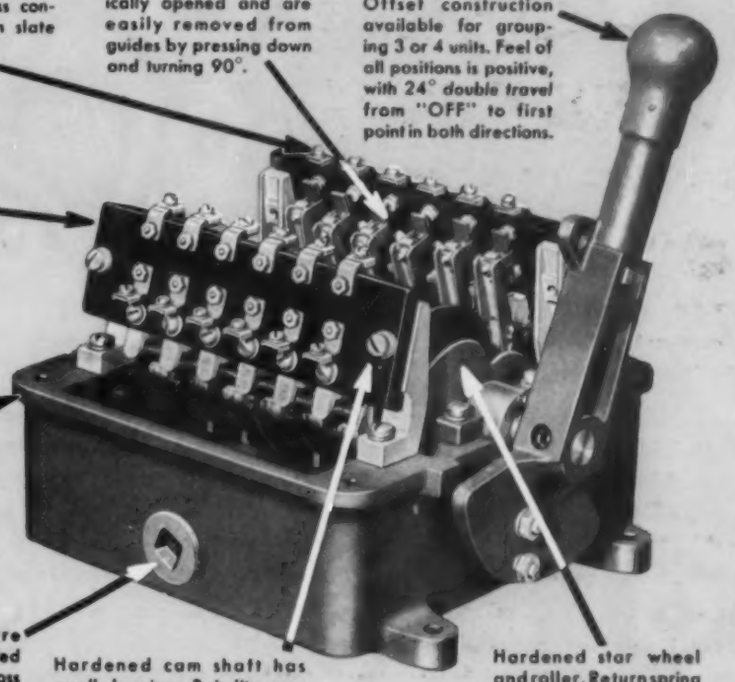
AVAILABLE IN 1 TO 6 POINTS—*Reversing or Non-Reversing*

• Specifications for Square D's new Class 9003, Type AD master switch originated with Mill Engineers. Ordinary construction is not suitable for mill duty where production delays cannot be tolerated and maintenance must be kept at a minimum in spite of severe service. Compare these features with those of other master switches you have used.

Square D also builds the control with which master switches are used . . .



CLASS 7953 Reversing, Plugging Control for Crane Bridge Motor



Stationary contacts with accessible solderless connectors mounted on slate board.

Movable contacts are double-break, silver, spring-closed, mechanically opened and are easily removed from guides by pressing down and turning 90°.

Sturdy handle has "OFF" position latch and padlock feature. Offset construction available for grouping 3 or 4 units. Feel of all positions is positive, with 24° double travel from "OFF" to first point in both directions.

Terminal board support serves as guide to prevent accidental damage when cover is replaced.

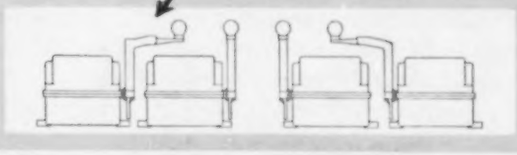
Dust-tight enclosure—split at bearing line for easy maintenance—has shallow box, deep cover and liberal space for internal wiring.

Conduit entrances are 1¼", conveniently located and have sufficient boss for redrilling and tapping to 1½".

Hardened cam shaft has needle bearings. Bakelite cams are bolted in position. Complete assembly has unusually wide electrical clearances and can be removed as unit.

Hardened star wheel and roller. Return spring pressure is adjustable.

Straight and offset handles combine to permit grouping of 3 or 4 units with 7" handle centers.



Write for information on CLASS 7950 SERIES Heavy Duty D.C. Control for Cranes and Mill Auxiliaries and CLASS 9003 Type Master Switches. Square D Company, 4041 N. Richards St., Milwaukee 12, Wisconsin.

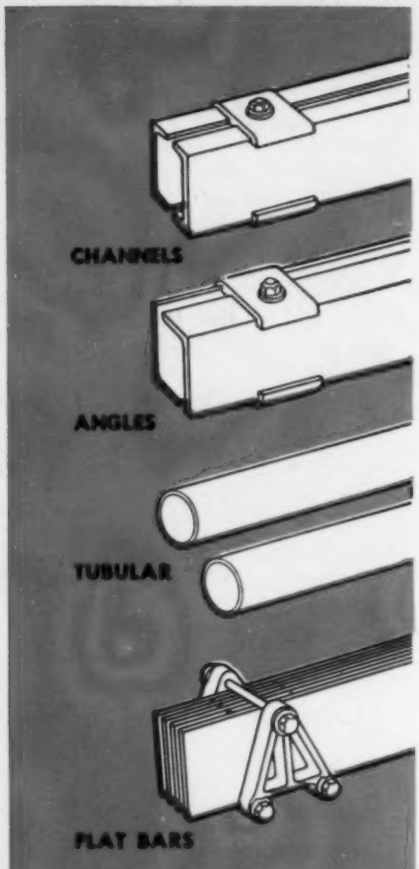
SQUARE D COMPANY

DETROIT • MILWAUKEE • LOS ANGELES

Here's a bargain for cost-worried electrical engineers...

ALCOA ALUMINUM BUS CONDUCTORS

Installation of 5" aluminum channels on 440-volt, 3-phase, a-c line.



Great rigidity

Long distance between supports

Fewer insulators

Cost less to install

Cost less to maintain

Cost less per amp. per foot

Alcoa Aluminum Bus Conductors come in stock sizes and in your choice of tubes, channels, angles, flat bars, or rounds. For same temperature rise, Alcoa Aluminum Bus Conductors weigh less than ½ as much as copper . . . require fewer supports and insulators . . . are easier and cheaper to fabricate and install.

Joints and tap-offs can be welded or made with bolted fittings of standard types.

Ask us for a copy of "Alcoa Aluminum Bus Conductors", a 52-page handbook of data and engineering advice to help you design and specify Alcoa Aluminum Bus Conductors.

ALUMINUM COMPANY OF AMERICA, 2128 Gulf Building, Pittsburgh 19, Pennsylvania. Sales offices in 54 leading cities.

ALCOA FIRST IN **ALUMINUM**

IN EVERY COMMERCIAL FORM

man in their Pittsburgh plant. In 1927 he became a junior engineer in the power department of National Tube Company at Pittsburgh, shifting in 1930 to the Ohio works of Carnegie Steel Company. Here he served successively as junior engineer, power and fuel engineer, and assistant chief engineer. In 1940 Mr. Williams was transferred to the Pittsburgh office of Carnegie-Illinois Steel Corporation as power and fuel engineer on the staff of the chief engineer, and was subsequently appointed assistant chief engineer of the Pittsburgh district. In 1941 he was placed in charge of a newly organized defense engineering staff to coordinate the engineering of defense steel plant expansions of the company in the Pittsburgh district. He was subsequently transferred to the United States Steel Corporation of Delaware as assistant to the vice president of engineering, and in 1943 to chief engineer of the Pittsburgh district, Carnegie-Illinois Steel Corporation, holding the latter position until his present appointment.

Mr. Williams is first vice president of the Association of Iron and Steel Engineers for 1948.

John W. Bates, formerly chief engineer of the Youngstown district of Carnegie-Illinois Steel Corporation, is now affiliated with Koppers Company. Mr.

JOHN W. BATES

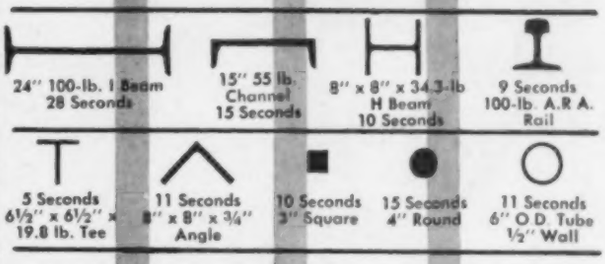
Bates is on special assignment with the new Pacific Steel Company plant at Concepcion, Chile, for which Koppers Company is supervising the engineering and construction.

Mr. Bates started his career with Duquesne Light Company and then went with the American Sheet and Tin Plate Company in the engineering department. In November, 1938 he was appointed electrical engineer for the Irvin works of Carnegie-Illinois Steel Corporation where he engineered and supervised the construction of the power lines for that plant. He later became superintendent of the hot strip mill at Irvin works. He then went with the Defense Plant Corporation installation at the Homestead works of Carnegie-Illinois Steel Corporation as project engineer. From this assignment he went to the chief engineer position in the Youngstown district, a position he held until his recent affiliation with Koppers Company.

A. H. Wardwell has been appointed director of raw materials, a newly-created post, for American Steel and Wire Company. Mr. Wardwell, who has been associated

Modern Sawing

with KLING HIGH SPEED FRICTION SAWS



Friction sawing is one of few mechanical processes which employ the heat of friction in a useful manner. It concentrates heat on the material to be severed at a rate which is faster than it can absorb heat. The immediate temperature rise of the contact surface is so great that its strength is reduced considerably lower than that of the colder blade rim. This heated surface is readily removed by the blade and permits complete severing of the material rapidly with no loss of metal from the blade.

Because of its versatile ability to cut many varied structural shapes, as well as solid or hollow bars in any sequence, without change of blade or set-up, one machine can handle a volume of cutting that would otherwise require several separate shears or slow speed saws.

Consult Kling engineers regarding your metal cutting problems. State size of material to be cut Bulletin No. 9200 giving full particulars and suggestions as to the type and size of saw will be mailed promptly. No obligation.

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WARE HI-LAG FUSE Construction establishes a top standard for rugged simplicity. There are only *3 PARTS* to handle to replace blown link:—the Fibre Case—the Knife-Blade Assembly—the Closure Ring. Only 1 wrench needed to loosen nuts and slip out blown link. Assembly can be inserted either end in Case.

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with U. S. Steel for 30 years, will be located in Cleveland. A native of Brockton, Massachusetts, Mr. Wardwell was educated in the public schools of that city and at Phillips Andover Academy before being graduated from Pennsylvania State College. Mr. Wardwell has worked his way up through the ranks, having started in 1917 as a pyrometer man in the blast furnaces at the National Tube Company's National works at McKeesport, Pennsylvania. He held other positions before being named superintendent of blast furnaces at that plant in February, 1922. From 1929 to 1935, he was blast furnace and raw material engineer in that company's general offices in Pittsburgh before transferring back to National works as assistant general superintendent.

In September, 1936, Mr. Wardwell was moved to Carnegie-Illinois Steel Corporation as assistant to general superintendent at South works, Chicago, Illinois. He was named director of industrial relations of Carnegie-Illinois in the Pittsburgh district in March, 1942. Since August, 1946, he has been supervisor of labor relations of that company.

C. F. McClurg has been appointed superintendent of power at Homestead works of Carnegie-Illinois Steel Corporation. Mr. McClurg, a graduate of the University of Pittsburgh with a degree in electrical engineering, started his business career with Duquesne Light Company. He then worked at the Schoen works of Carnegie-Illinois Steel Corporation at McKees Rocks, Pennsylvania. He later worked at the power plant at Homestead where he served as general foreman, power and fuel department.

A. J. F. MacQueen was appointed superintendent of electrical department at Algoma Steel Corporation, Ltd. Mr. MacQueen was born in Thessalon, Ontario in 1901 and attended public and high school in Sault Ste. Marie, Ontario. He worked several months in the electrical department of Algoma Steel and then attended the University of Toronto, graduating in 1925 with the degree bachelor of science in electrical engineering. After his graduation, he spent two years in the General Electric Company test department in Schenectady. He went with Sharon Steel Corporation in 1927 in the electrical department and was made assistant chief electrician in 1930. He went with Rotary Electric Steel Corporation, Detroit in 1936 in charge of the electrical department and later was put in charge of both electrical and mechanical maintenance. He was with James Stewart Company for one year of electrical design in connection with a new steel plant in Chicago. He went with Atlas Steels, Ltd. at Welland, Ontario, in 1943 as superintendent of electrical and mechanical maintenance.

William O. Bishop was appointed technical assistant, blast furnaces at Algoma Steel Corporation, Ltd., on October 27, 1947. Mr. Bishop was born in Philadelphia, Pennsylvania, October 29, 1911. He attended Pennsylvania State College 1929-33, graduating with bachelor of science degree in metallurgical engineering. He was with Republic Steel Corporation, Youngstown, Ohio, plant, blast furnace department from June 1933 to October, 1940. Following service with the ordnance

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So quiet, so dependable, so completely undemanding of attention . . . that plant engineers almost forgot it was there . . . the 90 horsepower motor pictured above remained continuously in operation for *eighteen* years! During that time so little attention was given the motor that the operators of the flour mill where it was installed forgot the name of the maker whose motor was serving so well. After eighteen years the motor was repaired for the first time. When the accumulation of flour and dust was removed from the caked nameplate it was discovered to be a Wagner wound-rotor Motor.

Users of motors have discovered that the name Wagner is a synonym for reliability and that motors bearing this famous name will give continuous, trouble-free service.

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Pictured above is a Wagner totally-enclosed fan-cooled motor which is recommended for dusty, dirty locations. Wagner makes a complete range of motors for every application.

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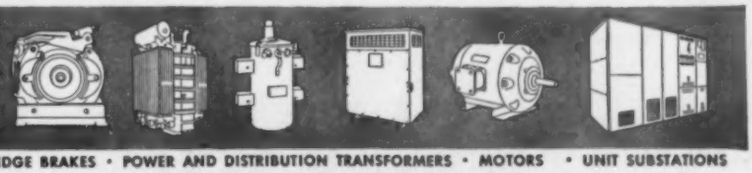

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CHIKSAN has adopted forged steel for all Styles and Sizes to and including 2"...in the following pressure ratings: 1,000 psi, 3,000 psi, 12,000 psi and High Temperature (700 psi, 500° F.). This important development now brings even higher quality to CHIKSAN users everywhere. It is tangible evidence of CHIKSAN's policy for continuous development in the design and manufacture of Ball-Bearing Swivel Joints for all purposes.
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BALL BEARING SWIVEL JOINTS FOR ALL PURPOSES
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Houston 1

department of the Army of the United States, where he attained the rank of lieutenant colonel, he went with E. J. Lavino and Company from March to December, 1946 as assistant superintendent of the Sheridan, Pennsylvania plant. From December, 1946 to October, 1947 he was assistant general superintendent of the Phosphor Bronze Smelting Company in Philadelphia, Pennsylvania.

E. S. Bowerfind, who for the past 14 years has been associated with Hill and Knowlton, the public relations firm which has represented Republic Steel, will be director of public relations for the newly formed public

E. S. BOWERFIND

relations department of Republic Steel Corporation. A native of Adrian, Michigan, Mr. Bowerfind attended school in that city. He worked for several years on Cleveland newspapers in editorial, advertising and promotional capacities. Before his association with Hill and Knowlton he was a member of the industrial development department of the Cleveland Chamber of Commerce. He had an active part in the Great Lakes Exposition, the promotion of the Cleveland Freeway System and many other civic activities.

Henry W. Hopwood, formerly employed by Hill and Knowlton, will be assistant director of public relations for Republic Steel Corporation. Mr. Hopwood is a graduate of University School and Colgate University. He worked as a reporter for the Cleveland Plain Dealer prior to the recent war, during which he served four years in the U. S. Navy, returning to inactive duty with the rank of lieutenant-commander.

William D. Martin, editor of Republic's employee magazine, *Republic Reports*, will be a member of Republic Steel Corporation's new public relations department. He has been associated with Republic for the past 14 years in advertising and sales promotion capacities. Formerly he was with the *Canton Repository* and with other newspapers in Pittsburgh, Chicago and St. Louis.

V. C. Orange was appointed as maintenance and service superintendent of Atlas Steels, Ltd., Welland, Ontario, Canada. Mr. Orange was born in Boston, Massachusetts, and commenced his career in the steel industry with the Colorado Fuel and Iron Company at Pueblo, Colorado, as an apprentice and later as journeyman machinist. Leaving this trade to study mechanical

How 19,000 companies up take-home pay *without upping payrolls*

Can you deduct $18.75 from $60.00 and get $66.25? *Yes.* And the way you can do it is mighty important to your company—and to the nation!

You start with $60, representing someone's weekly take-home pay. You deduct $18.75 for the purchase of a U.S. Savings Bond. That leaves $41.25. But $41.25 isn't what the worker takes home. He takes home $41.25 *plus a $25 Savings Bond.* Total (assuming he holds the Bond till maturity): *$66.25.*

WHAT 19,000 COMPANIES HAVE LEARNED

In the 19,000 companies that are operating the Payroll Savings Plan for the regular purchase of Savings Bonds, employees have been more contented in their jobs—absenteeism has decreased—even accidents have been fewer!

Those are the "company" benefits the Plan provides, in addition to extra security for individual employees.

But the Plan has other, far-reaching benefits of basic importance to both your business and the national economy . . .

SPREADING THE NATIONAL DEBT HELPS SECURE YOUR FUTURE

The future of your business is closely dependent upon the future economy of your country. To a major extent, that future depends upon management of the public debt. Distribution of the debt as widely as possible among the people of the nation will result in the greatest good for all.

How that works is clearly and briefly described in the free brochure shown at the right. Request your copy—*today*—from your State Director of the U. S. Treasury Department's Savings Bonds Division.

ACTION BY TOP MANAGEMENT NEEDED

The benefits of regular Bond-buying are as important today as ever—but war-time emotional appeals are gone. Sponsorship of the Payroll Savings Plan by a responsible executive in your company is necessary to keep its benefits *advertised to your employees.*

Banks don't sell Savings Bonds on the "installment plan"—which is the way most workers prefer to buy them. *Such workers want and need the Payroll Savings Plan.*

Those are the reasons why it's important to make sure that the Plan is adequately maintained in your company.

The State Director will gladly give you any assistance you wish.

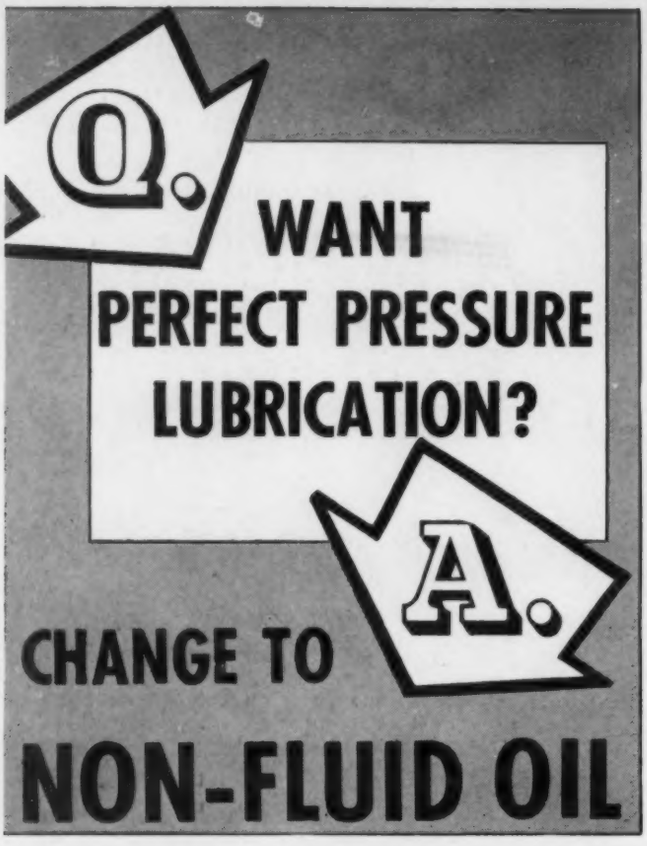
"The National Debt and You,"

a 12-page pocket-size brochure, expresses the views of W. Randolph Burgess, Vice Chairman of the Board of the National City Bank of New York—and of Clarence Francis, Chairman of the Board, General Foods Corporation. Be sure to get your copy from the Treasury Department's State Director, Savings Bonds Division.

The Treasury Department acknowledges with appreciation the publication of this message by

IRON AND STEEL ENGINEER

This is an official U.S. Treasury advertisement prepared under the auspices of the Treasury Department and the Advertising Council



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engineering, he returned to the steel business several years later, to become master mechanic of the billet mills with the Gary plant of Carnegie-Illinois Steel Corporation. Following, Mr. Orange was then associated with several large steel corporations in the United States, including Jones and Laughlin, Bethlehem, Inland and Republic, where he held various supervisory positions, both in production and administration. He joined the Atlas Steels, Ltd., in 1941, as superintendent of forging and production machine shops.

Roy E. Murphy was elected vice president in charge of sales for I-T-E Circuit Breaker Company, Philadelphia, Pennsylvania. He will be in charge of I-T-E sales programs, and coordinating the combined selling of I-T-E and its new subsidiary, the Railway and Industrial Engineering Company, Greensburg, Pennsylvania. Mr. Murphy has been associated with the I-T-E Company since 1934, as sales manager and member of the board of directors. Prior to his association with the I-T-E Company, Mr. Murphy had been identified with the sale of electrical products as sales manager for the Esterline-Angus Instrument Company, from 1922 to 1932; and as operator of the Pittsburgh sales agency for that company, and other instrument manufacturers, from 1932 until 1934.

ROY E. MURPHY

J. Fred Getz was promoted to the position of sales manager of I-T-E Circuit Breaker Company with complete control over the sale of switchgear products. Mr. Getz has been with I-T-E- since 1944, serving in the various positions of manager, Washington, D. C. office; manager, switchgear sales in the home office; and lately, assistant to the president. Before joining I-T-E, Mr. Getz was a member of the General Electric Company for over eight years.

Frank L. Estep, electrical and mechanical engineer who has been active in the steel industry since 1900, has become associated with the Barium Steel Corporation, Canton, Ohio. Mr. Estep will supervise and advise on activities of the 16 subsidiaries of the Barium Steel Corporation. He has been associated with such companies as the Cambria Steel Company and the Tennessee Coal, Iron and Railroad Company in this country as well as the Nova Scotia Steel and Coal Company of New Glasgow and other organizations in Europe, Mexico and India.

L. F. McCaffrey, special engineer for the metal industries in the Allis-Chalmers industrial sales department, is now located in the company's Pittsburgh district office. Mr. McCaffrey's services will continue to be available to all of the company's regional, district, branch offices and product departments on matters concerning steel industry problems, and he will lend assistance in coordinating and developing a metal industries group within Allis-Chalmers district office organization.

Prior to joining Allis-Chalmers in 1945, Mr. McCaffrey served as assistant works manager in charge of operation at the Algoma Steel Corporation, Ontario, Canada. He was previously employed by Jones and Laughlin Steel Corporation, Crucible Steel Company, Weirton Steel Company, Ford Motor Company, and the Republic Steel Corporation.

William H. Collins was appointed director of advertising for Dravo Corporation. Mr. Collins comes to Dravo Corporation from the Scott Paper Company of Chester, Pennsylvania, where he has been employed as assistant advertising manager since 1937. A native of East Orange, New Jersey, he was graduated in 1929 from Williams College, Williamstown, Massachusetts, and has attended the Universities of Grenoble in France and Heidelberg in Germany. He was adviser to the U. S. Delegation at the Fifth International Conference on Public Instruction at Geneva, Switzerland.

N. George Belury has been appointed vice-president of the engineering castings division of the American Brake Shoe Company, and **Harry C. Platt** has been named works manager.

Mr. Belury, formerly sales manager, has served in various sales capacities since he joined the Brake Shoe Company in 1937 after completing his studies at Purdue University. Mr. Platt, formerly division metallurgist, has been with Brake Shoe's metallurgical department since 1942 when he was graduated from Massachusetts Institute of Technology. Both men will continue to be located at the division headquarters in Rochester, New York.

John S. Lear acted as engineering consultant for John P. Ludgate Associates of Pittsburgh who recently sold the sheet mill equipment and facilities of the Algoma Steel Corporation at Sault Ste. Marie, Ontario, Canada to Portsmouth Steel Corporation of Portsmouth, Ohio. Mr. Lear was formerly chief engineer and assistant to the president of Tate-Jones and Company, Inc., and has been employed as chief draftsman and control engineer for the Loftus Engineering Corporation of Pittsburgh.

H. P. Etter, formerly sales manager of Air Reduction Company's Pacific coast division, has been elected president and director of a new wholly owned subsidiary which is named Air Reduction Pacific Company. The other directors will be: **C. D'W Gibson, G. E. Hawkins, J. A. Hill, C. G. Andrew** and **W. C. Keeley,** who will also serve as chairman of the board. Mr. Etter will make his headquarters at Room 1813, Mills Tower, 220 Bush Street, San Francisco 4, California.

William F. Bell has been announced as a director and vice president in charge of production and engineering for Southern Electric, Inc., Hammond, Indiana. Mr. Bell is a graduate of Carnegie Institute of Technology.

Obituary

E. H. Windolph died recently. Mr. Windolph was, for the past 35 years, a member of Alliance Machine Company's engineering staff and was in charge of the structural division. He was born at Canton, Ohio, on January 21, 1888, and attended grammar school and McKinley High School in Canton. He started work

E. H. WINDOLPH

with the Massillon Bridge Company in Massillon and also worked for several years with the American Bridge Company before joining the Alliance Machine Company's engineering staff. Mr. Windolph was a veteran of World War I.

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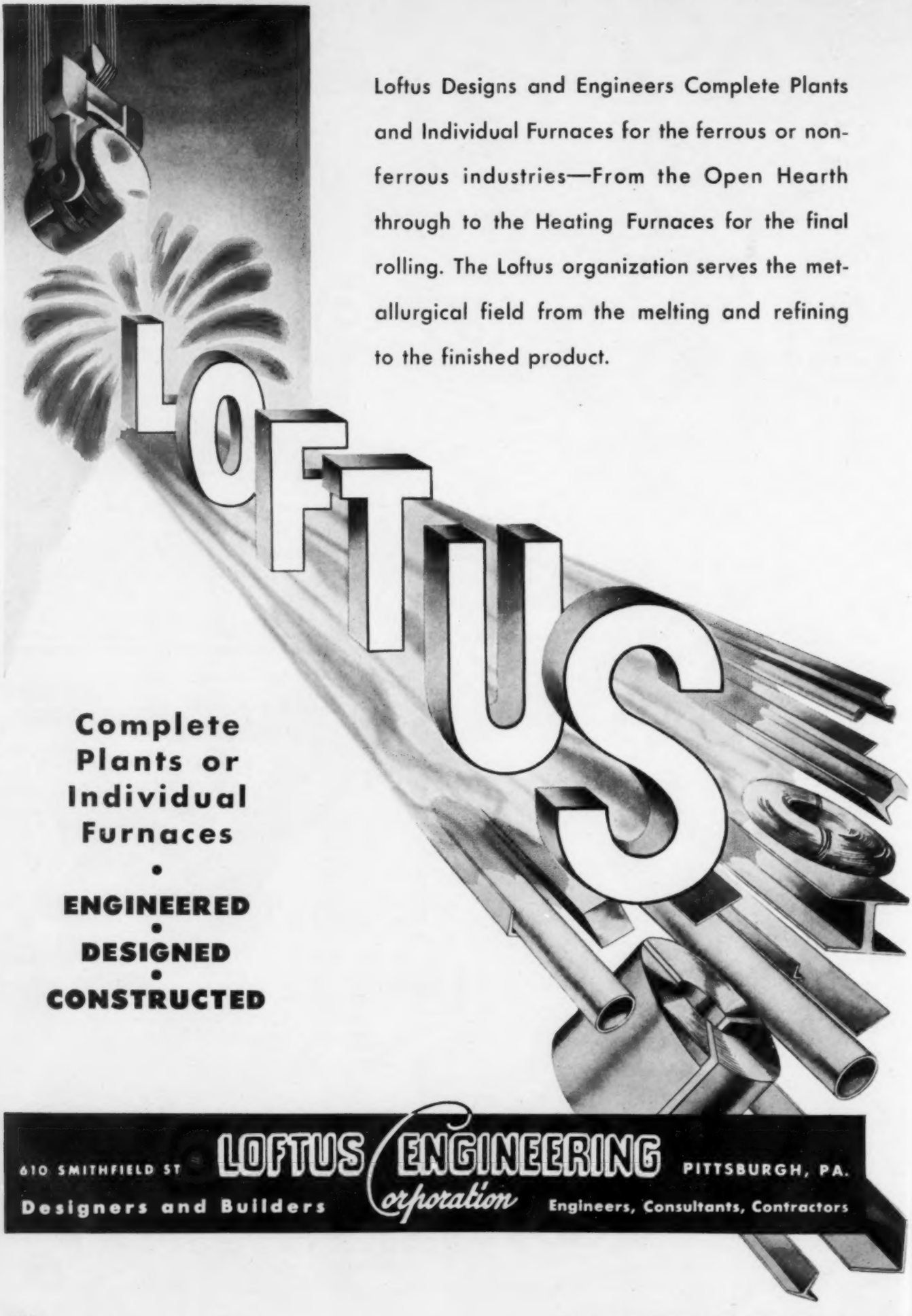

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DATE LINE DIARY

DECEMBER 1 — A series of "universities" in key cities throughout the nation for graduate engineers, staffed by practicing members of the profession, was announced before the council of the American Society of Mechanical Engineers. This will feature an innovation in engineering education and will act as an aid for the engineer just out of college who is starting his profession or practice. The pilot operation of the "university" is underway in Detroit. The Engineer's Council for Professional Development is the sponsor of the plan.

DECEMBER 2 — Steel production this week will be the largest of any peacetime week in history, and the largest since May 14, 1945, according to the American Iron and Steel Institute. The nation's steel mills will operate at 97.7 per cent of rated capacity.

TODAY the Weirton Independent Union, Inc., largest independent union in the steel industry, coupled praise for the Taft-Hartley Law with the announcement that its officers had filed anti-Communist affidavits. Thus, the union became the first known labor organization to defend the law.

LEADERS of the mineral industries of the nation have been invited by the Interior Department to meet with Secretary of the Interior J. A. Krug, on Friday December 12, to establish a National Minerals Advisory Council, with a view to advising the Secretary on the policy and program relating to the mineral supply position of the United States.

DECEMBER 3 — Production of domestic freight cars during November was 8,928 cars, the American Railway Car Institute announced.

THE Department of Commerce announced today that export controls will be extended to 36 more iron and steel products on January 1 next year. This action brings under control over 95 per cent of all steel mill products exported to all destinations except Canada. The action is the result of continuous shortages of steel for domestic needs. The additional products put under control will include (alloy and fabricated) structural shapes, including unfabricated over six inches; fabricated and unlined storage tanks; sheet piling and skelp; railway track materials and some semi-finished products.

THE new CIO wage drive was arousing alarm among Congressmen who are hunting for ways of cutting the cost of living. Both parties emphasized its potentially inflationary effects.

DECEMBER 4 — The Empire Steel Corporation, a Mansfield, Ohio sheet maker, was purchased by the Studebaker Corporation. This purchase was another indication of the present trend for the users of steel to acquire their own source of supply. Empire Steel Corporation has six open hearth furnaces with an ingot capacity of 348,000 tons annually and a finishing capacity for 120,000 tons of annealed sheets.

THE Fontana Steel Plant of the Kaiser Company established several new records for steel production. The open hearth set a new record of 73,579 tons or 19.6 tons per furnace per hour. The blooming mill broke its record for the sixth time producing 49,864 tons, and the soaking pits set a new record of 70,867 tons.

WILFRED Sykes, president of Inland Steel Company, stated today that the United States has ample supplies of ore and other resources to maintain its dominant position in the steel industry for centuries to come. He stated that although cheap and easily-mined ores may have a limited life, there is considerable low grade material that can be concentrated so that the price of steel will not be too greatly affected.

DECEMBER 5 — The Koppers Company will construct a 50,000,000 dollar steel mill in Chile. The company will supervise construction, engineering and management in a plant capable of producing 250,000 tons of finished steel products annually. This plant will be the first integrated plant in Chile. The location of the plant is at Concepcion on San Vincente Bay. The plant, using Chilean ore and coal, will go into operation in 1949. W. C. Snyder, Jr., vice president of Koppers' engineering and construction division will supervise the project.

A STEADY increase in the number of apprentices in the skilled trades has brought the number of those currently registered to 183,000, an all-time record, according to the Apprentice-Training Service, U. S. Department of Labor.

THE Carnegie-Illinois Steel Corporation announced that effective January 1, and applicable for 1948, new prices on electrolytic and hot dipped tin plate for can making will go into effect. The new prices are an average boost of $17 to $21 a ton.

DECEMBER 6 — Electro Metallurgical Sales Corporation announced today some changes in their price schedule, affecting principally alloys of silicon and chromium, which shall become effective January 1, 1948. The new base price for 50 per cent ferrosilicon is 9.3 cents per pound of contained silicon which is an increase of 0.5 cents per pound. Other increases included a raise of one cent per pound of contained chromium for higher carbon grades of ferrochrome. All grades of low-carbon ferrochrome are raised 1.5 cents per pound of contained chromium, except 2 per cent carbon grade which is up 1.75 cents, and the SM grade which is up 2 cents.

SECRETARY of the Interior announced today that emergency measures are underway to assure that the vital Illinois River waterway is kept open this winter for the movement of more than a million tons a month of coal, oil, and other essential commodities into the greater Chicago area. The Department of Commerce, through the Inland Waterways Corporation, and the Army Corps of Engineers, have agreed to undertake to keep the channels and locks of the waterway sufficiently free of ice to permit maximum barge traffic. The operation will cost about $250,000.

DECEMBER 7 — The Portsmouth Steel Corporation has purchased a Canadian sheet and tin mill which will be moved to Portsmouth, Ohio. This plant is capable of producing 100,000 tons of sheet annually.

DECEMBER 8 — The American Iron and Steel Institute announced today that the operating rate of steel companies next week will be 97.7 per cent of capacity which represents no change from the preceding week.

DECEMBER 9 — Today the Youngstown Sheet and Tube Company sent its first shipment of pipe by air. A C-54 Army cargo plane took off with more than eight tons of conduit needed to complete work on a military project at Keesler Field, Mississippi.

DECEMBER 10 — It was reported today that major steel companies have been moving quietly but forcibly to wreck the black market steel racket.

STEEL rates the No. 1 spot on the Administration's re-control program as presented to the Senate yesterday. The recommendation, made by Commerce Department officials, was cautiously-worded. It proposed certain limited priority and allocation powers over iron and steel.

THE Koppers Company announced today that it plans to continue the operation of its St. Paul coke plant even after the city turns to the use of natural gas. A number of special contracts have been signed with several companies which produce coke on a basis that will allow it a small margin o fprofit.

THE American Iron and Steel Institute members and employees met today at the Copley Plaza for a technical meeting which is fourth in a series held by the Institute in four cities.

THE Hudson Motor Car Company has leased two-thirds of the 625,000 square foot former Shenango tin plate plant of the Carnegie-Illinois Steel Corporation in New Castle to produce steel sheets for automobile bodies. Equipment purchased will give the mill capacity to produce 100,000 tons annually. Hudson thus becomes the fourth major auto producer to enter the steel industry following the lead of Studebaker, Kaiser-Frazer and the Eord Motor Company.

DECEMBER 11 — The Big Four foreign ministers, in their first major agreement since they started their meeting, decided today to raise the limit of German steel production capacity from 7,500,000 to 11,500,000 tons a year.

THE New York Central and the Baltimore & Ohio railroads announced today that they would open at Toledo next spring the most modern coal and ore docks on the Great Lakes. These represent a $18,500,000 facility built jointly by the two railroads. The annual capacity of the docks will be 20 million tons of coal and 4½ million tons of ore.

NOVEMBER steel production established a peak for that month with the result that the output of steel for the first eleven months of 1947 exceeded the total for the full twelve months of any previous peacetime year according to the American Iron and Steel Institute.

UNDER plans recently completed, internal auditing work in certain subsidiary plants and companies of United States Steel Corporation located between Duluth and New Orleans, has been centralized in Chicago.

IN the second of the regular quarterly meeting between representatives of the steel producing subsidiaries of United States Steel and United Steelworkers of America held today in Pittsburgh, J. A. Stephens ,vice president, industrial relations, U. S. Steel Corporation of Delaware said the objective of these quarterly meetings is to develop friendly and cooperative relationships between representatives at all levels.

THE recent ICC meeting in Boston gave a strong hint that steel industry traffic may be diverted in increased measure from the railroads to other forms of transportation. This meeting is being held for the purpose of holding hearings on the railroads' requests for higher freight rates. It was stated that increased freight charges may not result in the intended additional income from freight rates because more material might be shipped by water and by truck.

DECEMBER 12 — Representative Hoffman of Michigan will ask General Clark today to produce a suppressed department of justice report recommending against the sale of a $100,000,000 plant to United States Steel Corporation for $30,000,000. The sale eventually was made despite the adverse recommendation, and several members of Congress have been unsuccessful in getting the unpublished report for the department of justice.

THE scrap shortage now threatening steel production will be partially overcome in 1948, when two large coal washing plants of United States Steel Corporation are put into service. The new plants, now being constructed in Pennsylvania and West Virginia, will make possible a four or five per cent increase in the output of iron.

DECEMBER 15 — George R. Fink, president of the National and Great Lakes Steel Corporations, was presented a citation by President Truman on December 11. This citation honored Great Lakes Steel for wartime production of 95 per cent of the light armor plate used in Navy landing barges and 150,000 Quonset buildings.

THE operating rate of 94.0 per cent of capacity next week will be 97.8 per cent or an increase of 1–10 per cent over the previous week. This represents another peace time high.

DECEMBER 17 — Major steel manufacturers tacitly agreed today to a three-point program for combating the gray market in nails. The manufacturers agreed to try to accomplish better policing of their own mill shipments, increase output, and channel larger quantities of nails into the worst gray market spots on the theory that adequate supply will speedily kill the gray market.

GEORGE D. Branston until recently vice president of Campbell and Cannon Foundry Company, Muskegon, Michigan, will represent the foundry industry on a special mission sponsored by the U. S. Department of Commerce for the purpose of surveying accumulations of government-owned military scrap in Germany, and devising ways and means of expediting its return to this country.

DECEMBER 18 — It was just announced that the Cuyahoga Valley Railway Company serving the Otis Works of the Jones & Laughlin Steel Corporation is the winner in the railroad group competing in the Seventeenth Annual Greater Industrial Safety Campaign.

THE 147,000 tons of scrap bought from the U. S. Army by the Canterbury Corporation is coming back for use in the American steel mills This decision follows months of maneuvering between this country and European governments which requested that this scrap be diverted for their use.

DECEMBER 19 — The apparatus department of General Electric Company today announced a new price protection policy. It provides for 20 per cent limitation on price increases, if any, and simultaneously permits the company on new orders to adjust prices within this ceiling to those in effect at time of shipment. The policy covers all orders received December 5 and after and applies to the company's apparatus lines.

DECEMBER 22 — Shortages of scrap steel are so acute that many foundries plan to close over the Christmas holidays to permit an accumulation of raw materials

THE operating rate of steel companies for next week will be 86.6 per cent of capacity or a decrease of 11.5 per cent from the previous week. The reduction represents primarily the influence of the Christmas holidays.

CHARLES E. Wilson, president of General Electric Company, said that the new year should be a better one for industry than 1947. The industrialist held that the nation does not face a recession, and even if all foreign business were lost, he insisted, domestic demand would absorb production. In addition, he could see no chance for losing the foreign business.

DECEMBER 23 — Stockholders of Bethlehem Steel Company at a special meeting approved an increase in the authorized common stock from 5,000,000 to 20,000,000 shares, and authorized a three-for-one splitup of the stock.

INDUSTRIAL production increased during November to the highest point in peacetime history according to the Federal Reserve Board. Industrial output moved up to 92 per cent above the 1935-39 average on the board's seasonally adjusted index after a 2-point rise in November, third consecutive month to show an increase.

W. A. HARRIMAN, secretary of commerce, today summoned 15 top steel executives to Washington on January 8 to draft voluntary agreements for increasing production and channeling scarce steel to the most essential users. This is the first action taken under the new price bill. Walter S. Tower, president of the American Iron and Steel Institute, announced immediately that the industry is ready to discuss the question of voluntary allocations for steel products.

PRICES of gray-market sheet steel have gone up from 50 to 100 per cent in the last four months. The prices range from three to four times those charged by legitimate steel makers. Stamping manufacturers unable to get sufficient sheet steel are facing the prospect of closing their businesses.

DECEMBER 24 — The railroads have advised the ICC they will double their first quarter capital expenditures compared with the same period in 1947. The larger program stems from increased confidence in the near term future of the carriers plus the greater availability of equipment.

DECEMBER 26 — Sharon Steel Corporation announced purchase of a 65-oven by-products coke plant from Domestic Coke Corporation at Fairmont, West Virginia. Sharon Steel bought this from Standard Oil Company and will take possession early in January. The plant has a capacity of 25,000 tons of coke monthly.

DECEMBER 28 — More steel was produced by the American steel industry in 1947 than any peacetime year in a statement made by Irving S. Olds, chairman of the Board of Directors. He stated, however, that the achievement of higher output next year is dependent upon a number of factors, chief among which is a suitable supply of raw materials. Scrap steel has not been available in recent months. He also stated that United States Steel alone is spending more than $500,000,000 on a construction program designed to enable it to supply customers with increased quantities and qualities of steel to the end that supply will meet demand for many steel products as soon as possible.

DECEMBER 29 — The operating rate of steel companies will be 96.4 per cent of capacity next week which is an increase of 11.3 per cent over the previous week.

DECEMBER 30 — The quarterly dividend of 75 cents a share on the common stock of the American Can Company was declared by the directors today. The chairman stated at this meeting that the company's sales for 1947 will be the largest in its history and increased earnings will be the natural result of this larger volume.

DECEMBER 31 — George H. Love, president Pittsburgh Consolidation Coal Company, stated that one of the outstanding jobs in this country in 1947 was that done by the coal industry and its mine workers, aided by the railroads, in meeting the essential needs of an unprecedented world wide demand for coal. This record peacetime output of 600 million tons was accomplished without major additions to the industry's deep mine capacity, with a 1¼ hour reduction in the working day during the latter half of the year, and despite the difficulties caused by greatly overtaxed transport facilities.

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IN a blast furnace power house, the gas engines driving generators were lubricated by hand. Each engine kept one man busy all the time filling and adjusting grease cups for 256 bearings. Nine engines required the full time of 27 oilers per 24-hour day, 365 days a year.

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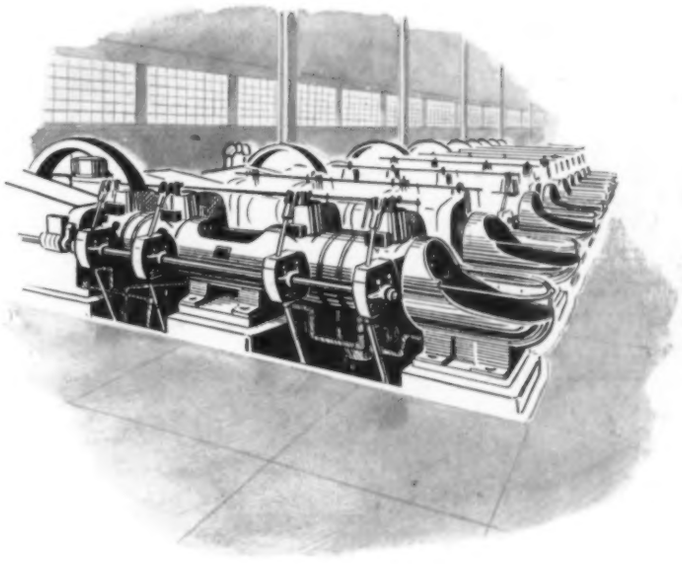

Adequate lubrication eliminated all metal-to-metal contact at bearings. There is less drag on the engines. Bearing replacement is no longer a problem. Engines run cooler, operate smoothly and quietly. The men are enthusiastic about Farval.

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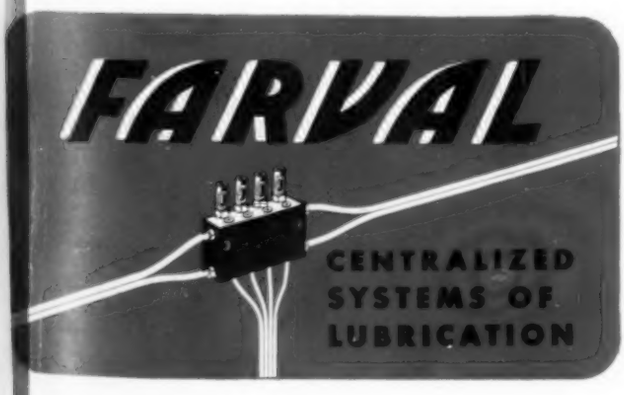

FARVAL—*Studies in Centralized Lubrication*
No. 89

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Protect Your High-voltage Motors with LIMITAMP CONTROL

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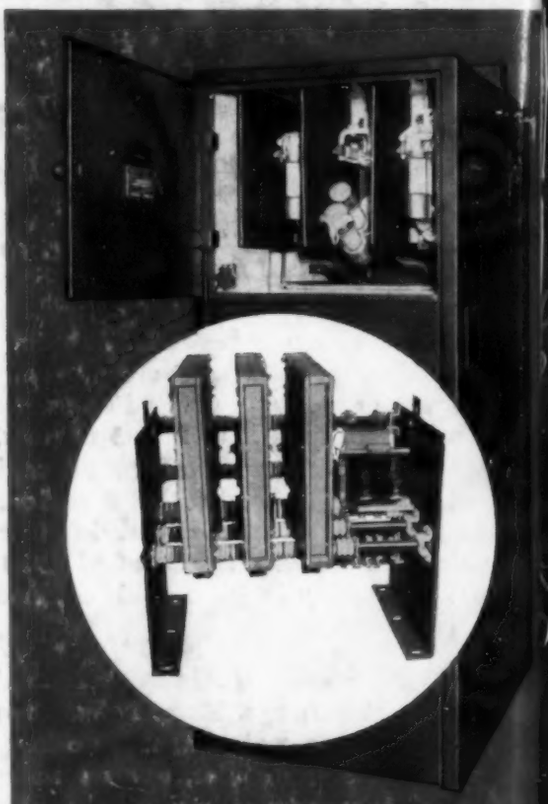

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